A GUIDE TO THE BEETLES OF AUSTRALIA

GEORGE HANGAY AND PAUL ZBOROWSKI

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Preface

The aim of this book is to help the reader recognise most beetle families that may be encountered in Australia. We have tried to do this by presenting brief descriptions of 17 superfamilies as well as 91 families – about 80 per cent of the beetle families occurring in Australia. We have also provided sample selections of as many subfamilies, genera and species as is possible within the confines of a guide book. Families which are poorly represented in Australia or rarely seen by non-specialists have been omitted. As a general rule we have tried to restrict descriptions of the morphological features of the beetles by focusing on those which can be examined by a hand-held 10x magnifier. However, a great percentage of beetles are very small, necessitating the use of a stereoscopic microscope.

The taxonomy in this book is based on Families and subfamilies of Coleoptera by JF Lawrence and AF Newton Jr, appearing on pp. 779–1006 of *Biology, Phylogeny, and Classification of Coleoptera; Papers Celebrating the 80th Birthday of Roy A Crowson,* published by Museum i Instytut Zoologii PAN, Warszawa, in 1995. We have made some alterations to reflect recent changes in the classification of beetles.

The natural history of beetles is fascinating and in the introductory chapters we have presented some of the basic facts relating to these amazing insects. The family chapters with about 400 illustrations give descriptions of the beetles, their names, distribution and some information regarding their habits and biology.

Common names were used in accordance with existing Australian, American and British publications, but the correctness of these are often arbitrary and many alternative names exist.

The sizes, given in millimetres, indicate the total length of a beetle, from the front of its head to the very end of its abdomen. Most of the specimens in the illustrations were photographed live in their natural habitats and afterwards set free. Consequently measurements couldn't be taken absolutely accurately and the sizes given in the captions are approximate only.

Those readers who are new to entomology may find many unfamiliar words in the text. These words – usually derived from Latin or Ancient Greek – form the language of entomology. This language helps to describe or explain something in a relatively short and concise manner. An extensive glossary is provided at the end of this book.

Unless otherwise stated, all the photographs in the book were taken by Paul Zborowski, while the text is mainly the work of George Hangay. This project was a difficult task, but a great learning experience for both authors.

One of the greatest coleopterists of our time, the late Dr Elwood C Zimmerman wrote: 'Those who know most about this subject know best how little they know.' How true this is!

George Hangay
Paul Zborowski

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Acknowledgements

To produce a guide book to the beetle fauna of Australia is a daunting task. Even such a modest work as this one requires much specialist knowledge. We asked a number of coleopterists to help us with our work. Dr Chris Reid assisted us significantly by reading the manuscript and correcting it where it was necessary. He also helped by identifying many of the Chrysomelidae and some of the other species illustrated. His help is most appreciated.

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We gratefully acknowledge the excellent resources provided by the Australian Museum's FaunaNet website. We have obtained most valuable information from it, regarding flower chafers and Christmas beetles.

We are also very grateful to all those authors whose publications we have used to gather information for this book. Some specific references can be found in the endnotes, but we couldn't possibly find room for all; they are too numerous to mention here, as their work would fill an entire library.

Mentioning all these eminent coleopterists should not be perceived as a disguised disclaimer. Any errors in identification or other faults in the text result from our own assumptions or misinterpretation of correct advice received.

We also would like to thank Mr Phil Colman, who kindly assisted us by reading and correcting the earliest versions of the introductory chapters. We are indebted to Dr David Britton for allowing us to photograph some specimens in the Australian Museum's Coleoptera collection.

We are grateful for the ever-present expert assistance of Mr Nick Alexander of CSIRO Publishing and for the generosity of the publishers who allowed us to use some illustrations from their great book, *The Insects of Australia*.

The jewel beetle *Castiarina luteipennis* (subfamily Buprestinae) occurs in New South Wales, the Australian Capital Territory and Victoria. It lives in a variety of environments, including those at higher altitude. This specimen was photographed near the Putty Road, north of the Colo River, New South Wales, on flowering *Angophora*.

Introduction

Beetles make up about 40 per cent of all the insects known to science. We find them fascinating and enigmatic. In many cultures beetles were regarded as mystical creatures, giving rise to a great deal of superstition and myth. The ancient Egyptians, for example, worshipped the scarab beetle.

Today scientists have named and described more than a million insect species. It is speculated that once the exploration of Earth's fauna is completed – if that ever were to happen – the final tally would be around five or six million insect species. The estimated number of individual insects is even more staggering. According to some researchers there are about 300 million insects for every living person and their combined body mass would outweigh that of humans by 12:1.[1]

It is often said that beetles can thrive just about anywhere – they have successfully populated most environments on Earth except the oceans, the permanently frozen polar regions and the highest snow-capped mountains. In Australia we can even find beetles on the top of Mount Kosciuszko as well as in the frigid, sub-Antarctic wilderness of Macquarie Island.

There are beetles that make their home in deserts, in hot and steamy rainforests, in deep caves, in streams and lakes, in human dwellings and even on ocean-going ships. They are practically anywhere and everywhere. They live on just about everything. Some are predators, some are highly specialised and eat only certain plants or other organisms, while others thrive on decaying matter of all sorts, including excrement and cadavers.

What 'use' are beetles?

The roles of beetles in Nature is extraordinarily complex and their relationship with humans is not without problems. Our interests often clash – beetles sometimes want the same things as we do and we have to compete for valuable resources, such as food or timber, horticultural plants and other natural or manufactured products.

Some species have become the constant companions of humans – or at least our stored products. Consignments of cereals for instance often contain a whole fauna of small beetles, others travel with shiploads of timber, animal hides or leather, preserved meat, fish, also with fresh produce of all sorts and even in the nooks and crannies of new or used machines and vehicles. The Australian environment is especially sensitive towards these unwanted migrants. They are considered harmful – and not only to humans but to the natural environment as well.

Agricultural pests can cause serious damage to crops, and the necessity to control them gave rise to a specialised field of science: agricultural entomology. A great number of beetles damage forestry timber and the fight against them is an important entomological task. In this fight we sometimes employ some beetle allies as biological control agents.

Using beetles to fight other insect pests, eradicate unwanted weeds and other invading plants are amongst the basic methods of biological control. In Australia we have imported foreign species of dung beetles to process the dung of introduced large mammals (e.g. cattle) in order to improve pastures and reduce the populations of flies. And, of course, humans also eat beetles. Indigenous Australians in their traditional way consume various insects, mainly the larvae of the larger wood-boring moths and beetles. In similar cultures worldwide, entomophagy – as this practice is known – is also quite common. The nutritional value of beetle larvae is undoubtedly high.

The Botany Bay diamond weevil was one of the first Australian beetles described and named by Fabricius in 1775. It was collected on 4 May 1770 by Sir Joseph Banks at Botany Bay.[2]

Beetle studies

Our fascination with these interesting animals is still strong and many professional and amateur entomologists specialise in beetles, known by scientists as the Coleoptera. There are so many species that it is virtually impossible for anyone to know them all. For this reason, most coleopterists are highly specialised and have in-depth knowledge only of a particular segment of the world of beetles. They usually focus on a relatively small group, like a family or even just a subfamily or tribe of beetles. Other coleopterists focus their attention on one particular zoogeographical zone or even just a small area, such as a mountain range, national park or forest.

Australia's beetle fauna is far from being thoroughly explored. Our continent is huge, its environment is diverse and the number of coleopterists studying the Australian fauna is very small. The first Australian beetles were named by Johann Christian Fabricius in 1775, but serious beetle studies started only around the middle of the 19th century by William John Macleay, one of the most outstanding naturalists of his time. Other pioneers were George Masters, Thomas Blackburn, Herbert James Carter, Arthur Mills Lea and Thomas Gibson Sloane. Their research was continued by a number of others and is still being carried out today by a small number of highly recognised coleopterists at CSIRO and in various museums and universities around the country.

There are also a small number of amateurs who maintain private collections and conduct beetle studies. Every coleopterist, amateur or professional, contributes something to science. Even the seemingly most unimportant observations, recorded data or a well-curated collection can add to the knowledge of our biodiversity and the world we live in.

What makes a beetle?

The answer to this question is, at least partly, in their scientific name, Coleoptera, meaning 'sheath wings'. Beetles are supposed to have two pairs of wings, although in some groups the second pair is absent. Characteristically, their first pair of hardened or leathery wings, called elytra, form a kind of a sheath which, when folded meet in a straight line on the middle of the back, covering the membranous hind wings. Not all beetles have hind wings, but the 'sheath' wings are almost always present, although sometimes in a reduced form. These wings do not assist locomotion but sometimes serve as stabilisers or rudders during flight. They also protect the membranous hind wings when at rest, and form the roof to a cavity above the body which controls gaseous exchange, water retention and thermoregulation. The females of a few species are wingless, looking more like larvae.

Beetles have chewing mouthparts. However, the appearance of these can differ a great deal, depending on the kind of food the beetles live on. Some beetles have modified mouths to take in specific foods and some adults don't eat at all – their mouths are practically non-functioning.

A *Trigonodera* (Rhipiphoridae) beetle with open wings as it takes off. It uses its second pair of wings only for locomotion.

The prionine longicorn beetle has well-developed mandibles.

Prominent compound eyes are also characteristic of beetles – but there are exceptions: some species which live in darkness (e.g. in caves) are blind.

Beetles undergo a complete metamorphosis, which means that their lifecycle consists of four main stages: egg, larva, pupa and adult.

The body of most beetles is covered with a neatly fitting suit of 'armour', which gives the beetle protection and also serves as its skeleton. Beetles, like all other arthropods (and unlike vertebrate animals), don't have internal skeletons. Their soft body, muscles and internal organs are within the shell-like armour, which is aptly named the exoskeleton or integument. It is made up of a material known as chitin, composed of layers of protein held together by a strong and flexible polysaccharide. This composite material is enormously strong, as any

Most beetles have multifaceted, compound eyes.

The exoskeleton of soldier beetles (Cantharidae) is so soft, that their flimsy elytra rarely sit flat over their second pair of wings.

This ground-dwelling weevil, *Talaurinus fergusoni* (Curculionidae), is one of the hardest beetles. It has an almost impenetrable exoskeleton. Photo: O Kelly

budding coleopterist soon finds out. The cladding of some jewel beetles and weevils is so hard that it is virtually impossible to pierce it even with the sharpest insect pin and one needs to resort to a fine jeweller's drill in order to get the pins through them!

On the other hand, the exoskeletons of the members of some families, such as the soldier beetles (Cantharidae) and the blister (or oil) beetles (Meloidae) amount to no more than flimsy cuticles. However, these soft-skinned examples are not typical of the order of Coleoptera.

Chitin is impervious to most chemicals. The digestive juices of many animals cannot dissolve it and the chewed up, crushed exoskeletons pass through their alimentary canals virtually without chemical change. Particles of the crushed armour can often be seen in the droppings of vertebrate animals.

The various elements of the exoskeleton are held together by flexible, skin-like membranes, also composed mainly of chitin. The hardness, tensile strength and flexibility of chitinous tissue can vary greatly and its characteristics could change with the age of the specimens.

But there are disadvantages of living in armour. The main disadvantage is that it can't expand much, therefore the animal which it protects, can't grow. Adult beetles – and all other insects – don't grow. Individuals belonging to the same species may vary in size but it doesn't mean that the little ones eventually may catch up in size with the larger ones. The larger specimens had more or better food available for them in their larval stages, while the 'runts' had less and probably starved.

Beetle larvae also have exoskeletons. How come those larvae can still grow? The answer is quite simple – they moult. When a beetle larva hatches from the egg, it is small and usually quite soft. Its exoskeleton is flexible, which allows a certain amount of growth, but it soon reaches a point when it just can't expand any more. This is the time for the first moult or, as it is also known, ecdysis. The larva sheds its old skin and develops a somewhat larger and more flexible one instead. In some cases it may even be a little too big for the body and it may have some wrinkles, but it soon fills out as the business of all larvae is to eat and

Stages in the life of the flower chafer, *Heteroprotaetia fusca* (Scarbaeidae). From left to right: early and late instar larvae, pupa and adult beetle.

grow. It repeats this process until it reaches its final size, pupates and eventually changes into an adult beetle. This process is called metamorphosis (see also page 21). The stages between moults are called instars.

Some beetles produce a kind of pigmented powder that covers part or the whole of their exoskeleton. As these beetles move about, the powder can be rubbed off, showing the pigmented base colour underneath and making the older specimens look worn out. Some others are covered by coloured hair, also known as pubescence, which too can wear off, thus changing the appearance of the beetle.

Beetles are among the most colourful of all animals and colour (or the lack of it) is an important factor in the beetle's appearance. Some are black or dark brown, but others sport a range of solid reds, blues, bright yellows and white. Many of these pigments come from plants that the larva eats. They accumulate in the larva's system and through the metamorphosis they are passed on to the adult beetle. Dead beetles in antique collections retain their 'solid' colours for centuries; even direct sunlight or artificial light doesn't fade them rapidly. However, decaying fat content of their

The powdery coat of the greybacked cane beetle, *Dermolepida albohirtum* (Scarabaeidae), eventually wears off with age.

Some colourful beetles

Zonitis sp. (Meloidae).

Cyrioides imperialis (Buprestidae).

Illeis galbula (Cocccinellidae).

Chrysophtharta nobilitata (Chrysomelidae).

Coptodera mastersii (Carabidae).

Polystigma punctata (Scarabaeidae).

Some beetles with refracted colours

Curis caloptera (Buprestidae).

Eleale sp. (Cleridae).

Colasposoma sellatum (Chrysomelidae).

Anoplognathus aureus (Scarabaeidae).

bodies, chemical reaction to insect proofing agents, dust and mould may cause darkening and dulling of colours in dead beetles.

Chitin by itself is translucent, slightly yellowish-brown and if there are no pigments present in it, the colour of internal tissues can give a certain hue to a beetle. Because of this translucency, colours can be created by refracted light also. Some of the most brilliant colours in beetles are the results of this phenomenon. Light travelling through the layers of transparent chitin is refracted, creating mostly greenish, bluish, reddish and purple metallic colours. These colours vary with the amount, angle and nature of the light and it is quite possible that a particular specimen can appear blue, green, reddish or purple, depending on the angle and light in which we examine it.

Refracted colours, unlike pigmented colours, can change permanently after the death of the beetle. It is most evident in some preserved specimens of jewel beetles (Buprestidae) and some chafers (Scarabaeidae). This colour change is caused by the changes occurring in the layers of chitin during the preservation process and by the decay and oxidation of fatty tissues, directly under or within the exoskeleton.

Anatomy

Insect anatomy differs a great deal from the anatomy of vertebrate animals, including humans, but the head is probably the only part of the insect's body that bears some resemblance, in function at least, to the heads of higher animals.

The beetle head contains and protects the main nervous control centre. This is not quite a brain, but it is pretty close to it. Here we can find brain-like nerve centres called ganglia and a number of other important organs. Information gathered by the eyes and other sensory organs such as the antennae is quickly transferred and processed here and appropriate reactions are triggered. Undoubtedly the ganglia are more primitive organs than the brains of higher animals but their function is still incredibly complex and effective. The survival of insects through the millions of years greatly depended on their behaviour and adaptability to ever-changing environments and conditions. If you consider that all this is governed by impulses and reactions coming from the insect's head, which can be as tiny as a minuscule fraction of a pin's head, you can't help but admire these animals.

The positioning of a beetle's head is an important morphological feature. A forward pointing head, with mouthparts at the front is known as prognathous, but if it is bent downward at right angles to the body, it is called hypognathous. When it is bent down even more, as trying to curl under the body, with mouthparts pointing towards the rear, it is an opisthognathous head.

Eyes

A typical beetle has two large compound eyes. These are made up of lots of individual, six-sided eyes, called ommatidia. The complexity of a beetle eye depends on its use. Species that depend a lot on their sight have large compound eyes, consisting of many ommatidia, while

The positioning of a beetle's head is an important feature. Depending on which direction its mouthparts point, it is called opisthognathous (left), hypognathous (middle) or prognathous (right). Drawing: G Hangay

Melittomma sp. (Lymexylidae). This beetle has large compound eyes.

those that have little use for keen eyesight developed simpler eyes. Beetles living in the permanent darkness of caves for instance are blind, with eyes absent or having just vestiges of them, perhaps with some light sensitivity, but no sight. Among the most peculiar examples are some species of the very small feather-winged beetles (Ptiliidae). These tiny insects live in decaying plant material and excrement and, within the same species, one can find specimens with and without eyes.

In addition to compound eyes, some beetles – just like many other insects – also have simple eyes, called ocelli. Many beetle larvae have ocelli, but they can't be found so frequently on adults. The adult carpet beetles (Dermestidae), members of the rove beetle subfamily Omaliinae (Staphylinidae) and species of the Derodontidae family are best known for their ocelli. They are positioned on the top of the beetle's head, on the vertex, but their function is yet not fully understood. It is thought that ocelli serve to distinguish a faint image and light from darkness.[3]

Despite its complexity, the beetle eye sees the world as a somewhat blurred image. However, it detects movement readily and it perceives certain colours too. Experienced field workers agree with this, because they know that many species can be lured to colourful traps. Actually, different species prefer different colours; red, blue, violet and bright yellow being the most popular ones. Yellow seems to be a very attractive colour to many insects, not just beetles. Entomologists use plastic plates of this colour, filled with water to attract and trap a whole host of insects, but especially flies, wasps and bees. Yellow plates don't attract many beetles, at least not in Australia.

Antennae

All beetles have antennae, although they are often strongly modified. The antennae are composed of a number of segments – 11 being the most typical, while the greatest number known to adult forms seems to be around 40. (Male prionine longhorn beetles have 40 or even more segments each.)

There are beetles with simpler antennae with fewer segments – the antennae of some species have only two segments. Their primary function is to smell and probe, providing the beetle with important information about its environment, the shape of objects within its reach, the whereabouts of its mate, food, possible enemies and so on. The beetle's antennae can also perceive electromagnetic waves, infra-red radiation and can gauge the humidity of the air.

Beetles can smell the tiniest traces of odours, such as the pheromones of a mate or the appetising aroma of food. They gather this information through microscopic sense cells on the surface of the antennae, which sometimes seems to be disproportionately long. Some of the

The various types of beetle antennae

lamellate (Scarabaeidae).

serrate (Lycidae).

filiform (Carabidae).

elbowed (Curculionidae).

moniliform (Passandridae).

plumose (Rhipiceridae).

clubbed (Erotylidae).

longicorn beetles (Cerambycidae) have the longest antennae, although a few of the tropical snout beetles (Anthribidae) also have extremely long antennae.

Hairs, side branches and other expansions often enlarge the surface of the antenna – the larger the surface, the more sensory cells it can accommodate. The antennae of the superfamily Scarabaeoidea have several lamellate extensions at their extremities. These plates or lamellas can be spread, thus acting very efficiently as olfactory locators. Other beetles, such as members of the ground beetle subfamily Paussinae (Carabidae) also have highly developed, complex antennae.

The leopard longhorn, *Penthea pardalis* (Cerambycidae), has a chewing mouth.

The mouth of net-winged beetles (Lycidae) can be found at the tip of their rostrum.

The small mouthparts of this chafer (Scarabaeidae) are hidden by the clypeus.

Mouthparts

The jaws of beetles do not move up and down in order to chew as we do. Their two well-developed jaws or mandibles move horizontally, opposite each other, in a scissor-like motion. These are assisted by a pair of lower jaws or maxilla, operating just below them. Their jaws are capable of cutting or chopping food, digging or boring into solid matter in order to prepare a resting place for the beetle's eggs, and serving as weapons for offence or defence. The sharp jaws of predatory beetles are formidable hunting weapons. They can seize and kill prey, but usually do not chew it up. Instead many predators, such as ground beetles (Carabidae), bring up their digestive juice, pour it over their captives and as it dissolves their flesh, lick it up.

Male stag beetles (Lucanidae) have the greatest mandibles of all but do not use them for chewing. In fact adult stag beetles don't chew anything – most of them live on the sap of trees or the nectar of flowers and some don't eat at all. They use their dangerous looking 'antlers' mainly for show and in combat between rival males. They are handy in self-defence too, as they can deliver a very painful bite.

The lower mouthparts are made up of several components and are surmounted by multi-jointed maxillary palps. The lower lip or labium also has some palps. The palps usually look like smaller versions of the beetle's antennae and often serve as supportive organs. One of their main functions is smelling and tasting food, but they may also help certain species to sense the pheromones secreted by females.

The upper lip or labrum is a broad, plate-like structure which spreads over the mouthparts. At its base is a narrow

The tiger beetle (Carabidae) has prominent, large-jawed mouthparts.

The small, chewing mouthparts of weevils (Curculionidae) are on the end of a long rostrum.

The mandibles of this brown stag beetle, *Ryssonotus nebulosus* (Lucanidae), serve to signify its prowess as a male.

This male stag beetle, *Prosopocoilus torrrensis* (Lucanidae), uses its formidable 'antlers' in self-defence or in combat with rival males.

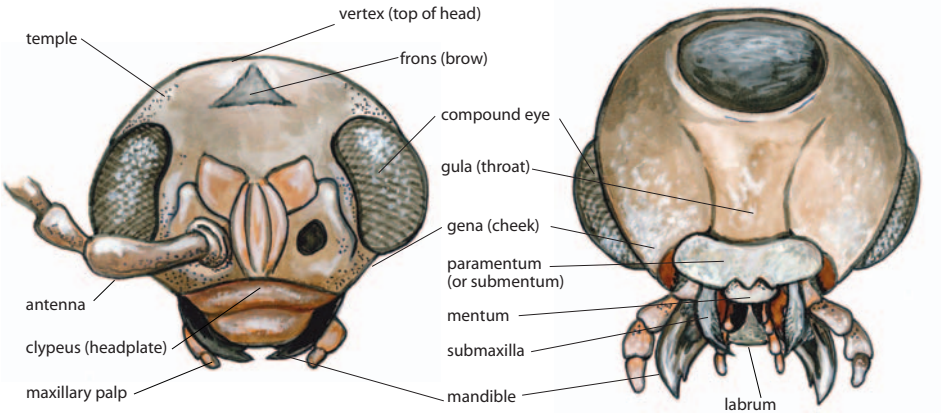
supporting strip, called clypeus. The upper and lower lips help to keep the food in line with the mouth as well as provide protection to the more vulnerable mouthparts.

Thorax

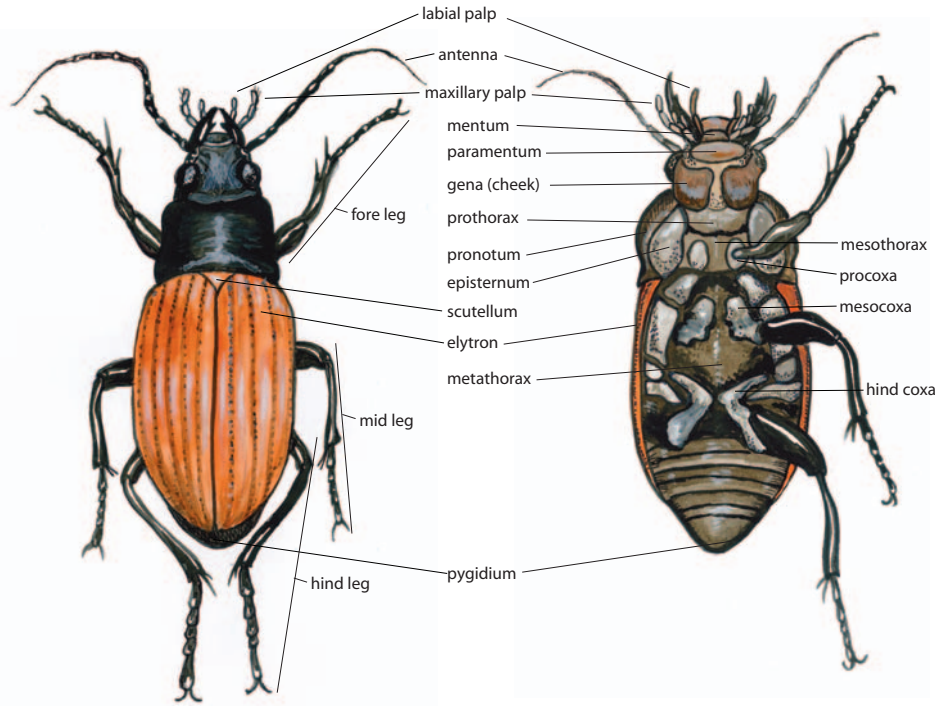
The thorax houses most of the muscles. It consists of three segments: prothorax, mesothorax and metathorax. These are fused together and, from the dorsal view, only the upper part of the prothorax and usually only a small section of the mesothorax are visible.

The dorsal part of the prothorax is called the pronotum, which forms a protective shield, while the small, usually triangular section of the mesothorax, which lies at the base between the elytra, is the scutellum. This little thoracic sclerite is often reduced or even absent, however, in most cases it bears important identification marks.

Each section of the thorax supports a pair of legs – the first pair point forward, while the other two point towards the rear.



The beetle head: dorsal view (left); ventral view (right). Drawing: G Hangay



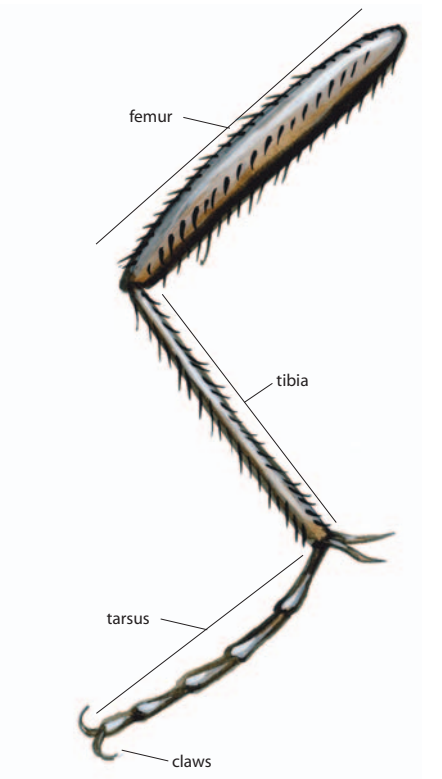
The beetle body: dorsal view (left); ventral view (right). Drawing: G Hangay

Different types of beetle legs (from left to right): for running, jumping, digging or swimming. Drawing: G Hangay

Legs

The shapes and functions of beetles' legs are very diverse. Obviously, the shape serves the function and usually it is not too difficult to guess what sort of a life a beetle leads, just by looking at its legs.

The legs of beetles can have many forms but their make-up is quite uniform. They all consist of the same major externally visible parts: coxa, trochanter, femur, tibia and tarsus. They are attached to the thorax by a 'ball and socket' joint, the coxa being the 'ball' which rotates in a hollow of the thoracic exoskeleton, known as the coxal cavity. The femur is usually the largest and strongest part, followed by the often long and slender tibia. The tarsus or foot is normally three to five segmented, the last segment bearing claws. The number of tarsal segments plays a major role in classifying beetles and they are often depicted by a tarsal formula. The typical beetle's foot is five-segmented on all three pairs of legs. This would give a formula 5-5-5. The feet of some species could have



Parts of the beetle leg. Drawing: G Hangay

fewer segments or the entire foot could be completely absent. To count the tarsal segments is not always an easy task, because occasionally a segment is so much reduced – although not missing – that it is difficult to recognise. Enlargement of the third segment which obscures the very much reduced fourth is probably the most common. A foot like that could appear to the inexperienced coleopterist as four segmented and thus lead to misidentification of the specimen. To render the situation even more difficult, descriptions of beetles often depict such feet as 'apparently 4-segmented'.

Wings

The first pair of wings, the usually hardened elytra, are attached to the dorsal side of the mesothorax and the membranous second pair underneath them, to the metathorax. Most beetles can be recognised by the colours and sculpturing of their pronota and elytra.

The elytra are sometimes quite small and reveal the folded flying wings to such degree, that the beetle resembles a wasp. This is just one of the many tricks that beetles have developed through millions of years in order to fool their enemies. Typical rove beetles (Staphylinidae) have very short elytra, but they fold their flying wings in a complex manner, very neatly underneath them. Rove beetles look very similar to earwigs (Dermaptera), which are of course not beetles at all, belonging to a different order. The easy way to differentiate rove beetles from earwigs is to see which one has two small appendages, called cerci, at the tip of their abdomen. The ones without are beetles and the ones with are earwigs.

There are a few beetles, which have no elytra at all. We find these among the Leptinidae, a family of beetles that lives in the fur of mammals and in the debris of their nests, the females of fireflies

The peculiar 'trilobite' beetle, *Dulticola* sp. (Lycidae), is found in the tropical rainforests of India and South-East Asia. Without elytra, this adult female looks like a larva.

This diving beetle, *Sandracottus bakewelli* (Dytiscidae), has so much air trapped under its elytra that a bubble protrudes out at the back.

(Lampyridae) and South-East Asian 'trilobite' beetles (Lycidae).

The elytra occasionally serve another purposes. For example, diving beetles (Dytiscidae) use them as air reservoirs. These aquatic beetles spend most of their lives underwater, but need to breath air. When they run out of it, they float up, just below the surface and poke their pointy tail end through it. They lift their elytra a little, just enough to allow the air to get underneath them. They draw in as much air as possible through their breathing pores and store the rest under their elytra, taking further breaths from this storage of air while underwater, not unlike a human diver uses an aqualung.

The second pair of wings is usually translucent, sometimes transparent, but in some species partially or wholly pigmented. They have clearly visible veins, often darker in colour than the wings themselves, which are hollow and carry air. To spread its wings, a beetle has to pump air into the veins in order to inflate them. Otherwise, when the beetle is not flying, the wings are always folded in a set pattern and usually fit neatly under the elytra. Some species can spread their wings and take to the air in a split second, while others take some time to become airborne. Tiger beetles (Carabidae: Cicindelinae) are perhaps the nimblest flyers. Most beetle collectors know this well, having suffered many frustrating hours trying to net some of these handsome, but very elusive critters.

In flight, the second pair of wings do most of the work. The elytra may act as stabilisers or even as rudders, but experiments have shown that their artificial reduction (by trimming them) does not reduce the ability of the beetle to fly.

There are many species of beetles without the second pair of wings. These flightless animals have no need for wings as they usually live on the ground or within decaying plant material. Among these species fused elytra are not uncommon.

Abdomen

Normally, the abdomen is the largest body part of the beetle. Unlike the head and the thorax, it is flexible to a certain degree. In most cases it is well protected from above by the elytra and by heavy armour on the underside of the beetle. It houses important organs, including the reproductive 'equipment', sperm of the male and fertilised or unfertilised eggs of the female, as well as fat reserves and of course water.

The abdomen is made up of a number of chitinous segments, often connected with a more or less flexible, skin-like tissue, which allows expansion. This is quite an important feature because the gravid females of many species, loaded with hundreds of eggs, can swell up enormously. The typical beetle abdomen consists of nine or ten segments. The dorsal parts of these are called tergites and the ventral parts are called sternites. Generally only five or six segments are externally visible.

The rear (apical) segments of the abdomen are often modified in various manner. In species, where the elytra are sort of 'square cut' – truncate – the last one or two segments of the abdomen remain exposed. The last one is known as the pygidium and the preceding one is the propygidium. Their complexity is important for taxonomists. But even more important are the often strongly sclerified sexual organs which are hidden under the apical sternites. The male organs, especially, are very often used to determine specimens.

What's inside?

Undoubtedly, the beetle is a very successful life-form of our planet. It is tempting to say that the secret of its success is the simplicity of its body. Tempting, but not true! Inside its chitinous shell is a hugely complex body.

The first major feature of the arthropod's anatomy, which is completely different from ours, is that all the muscles adhere to the inside of the skeleton. The exoskeleton, which may look rather complex from the outside, is even more intricate on the inside. The cavities within it are full of precisely formed protrusions, knobs, ridges and grooves, each serving as anchoring spots for muscles, cradles for internal organs and reinforcements to the shell itself.

There are not too many openings in the exoskeleton. There is of course one for the mouth, through which the animal takes its nourishment, then there is another one at the opposite end, where rubbish goes out. The same opening serves the sex organs as well. In between, usually on both sides of the beetle's thorax and abdomen, are the spiracles. These are small holes – not unlike portholes on the side of a ship – and their main purpose is ventilation.

Breathing

All adult insects, including beetles, breathe air, although some aquatic larvae that live in water can get oxygen through their gill-like breathing apparatus and by simple diffusion from the water.

Insects don't have lungs, but inhale air through their spiracles. The spiracles are entrances to a complicated system of tubes, known as the trachea. Air travels through this labyrinth of branched, chitin-lined and ever-narrowing pipes in order to reach the cells directly. The spiracles can open and close to regulate airflow and limit water loss.

Most beetles that can fly need to take in a lot of air prior to flight. Their abdomen literally pumps up in order to hold the larger quantity of air required to inflate their second pair of wings and to supply the body with an increased amount of oxygen

during the flight. In these beetles the tracheal system includes some large air reservoirs distributed throughout the body, including the head.

The circulatory system

Beetles – like all other insects – have an open circulatory system, which means that their 'blood', the haemolymph, is not circulating in a closed network of arteries and veins, like our blood does, but instead it fills most of the interior of the body and surrounds all cells. Haemolymph bathes the organs directly, supplying them with oxygen. Circulation is at low pressure, created by the pumping action of a simple heart, located in the dorsal area of the thorax. Body movements also assist circulation.

Haemolymph is composed of water, inorganic salts, carbohydrates, proteins, lipids and some other organic compounds. It is not red like the blood of vertebrate animals, but rather colourless, or sometimes yellowish or greenish.

Some species of beetles do have red or orange coloured liquids stored in their body, but it is not true blood. It is used as a repellent against possible enemies.When the beetle is disturbed it oozes this red substance, hoping to surprise and bluff its attacker.

Haemolymph also 'rinses out' wastes, particles of dead cells and bacteria. Their excretory organs, known as Malpighian tubes, remove salts and nitrogenous waste from the haemolymph and transport it to the digestive tract. There are four to six Malpighian tubes in a beetle. Toward the end of the tract, at the rectum, salt is pumped back into the haemolymph, followed by water through osmosis. The nitrogenous wastes are eliminated as almost dry matter, along with the faeces.

Beetles are very good at conserving water.

Beetles, mainly because of their tightly sealed exoskeletons, can conserve the water content of their bodies very efficiently, much better than we can. Their efficient water conservation has contributed to the tremendous success of these animals on land. Compared to them we – and many other mammals – are not much more than leaky bags of water, loosing moisture through countless openings of our porous skin and body orifices.

Sound and hearing

Most beetles create a sound by stridulation – by rubbing parts of their exoskeletons against each other. Some, like the death-watch beetles (Anobiidae), make a tapping or knocking noise. Undoubtedly, most beetles react to noise and it is generally accepted that beetles, which can make a sound, can also hear.

Not much is known about the hearing of beetles. Their hearing organs do not resemble the ears of the higher animals at all and they are not positioned on the head. The typical insect 'ear' has a thinned tympanic membrane and an airsac which are connected to sensory structures.

The organs are positioned differently in the various groups. In some cases (in some scarabs, for instance) the tympanic membranes of the beetle are part of its cervical membrane and are located behind the head, where the cervix attaches to the pronotum, while the tympana of the tiger beetles (Carabidae: Cicindelinae) are at the lateral margins of the first abdominal segment. Many species seem to perceive sudden, loud sounds and react in a defensive manner. It is difficult to tell if they really hear the sound or react to vibrations caused by it.

Bioluminescence

Some beetles can produce light biologically, known as bioluminescence. In Australia, only fireflies (Lampyridae) can do this. Fireflies are beetles, of course, and most Australian species are winged in both sexes. Luminescence is created by the oxidation of an organic compound by an enzyme known as luciferase, within the body of the beetle. The light is emitted by a special organ on the ventral side of the abdomen. Sexes of adult fireflies find each other guided by their lights, although their eggs, larvae and pupae also emit a faint luminescence.

Why do glow-worms glow?

The ability of the Lampyridae to glow at night has always intrigued humans. It fuelled superstition, helped to create fairy tales and inspired naturalists who wanted to find out more about these fascinating creatures. What is the reason for this bioluminescence?

The most obvious answer is that it serves courtship, the mate-location process. It is true that a cruising male finds a stationary female by homing in on the faint light which she generates. But why do lampyrid eggs, larvae and pupae glow?

European researchers suggest that the glow of non-reproductive forms more or less serves the same purpose as aposematic colouration in other insects. It is a kind of 'advertisement' that is intended to repulse possible attackers. Lampyrid larvae don't taste good, but being nocturnal, aposematic colours wouldn't help much. So it uses a warning light instead and insectivorous animals learn to associate this bioluminescence with a foul taste.[28]

The production of bioluminescence is a complex process, governed by the beetle's nervous system. It produces very little heat, so it can hardly be called a 'glow'. It is the result of a biochemical oxidation reaction within the body of the insect. When the beetle dies, the light goes out...

The underside of a firefly, *Atyphella* sp. (9 mm), reveals its 'lamp'. It flies in damp forests at night, flashing its light about once a second. *Atyphella* is found in the forests and woodlands of New South Wales, Queensland and the Northern Territory.

Reproduction and development

Beetles have male and female forms, with complex reproductive systems. The female usually exudes a scent, a sexual pheromone, which is in most cases undetectable by the human nose. But the olfactory senses of some beetles are much sharper than ours and males can 'sniff out' females of their own species from long distances. In some species or groups visual signals also help the sexes to locate each other.

Sperm develop in the male's testes and are stored in the seminal vesicles until they are transferred into the ejaculatory duct, which runs through the penis. Eggs of the female travel from the ovaries through the oviducts to the vagina to await fertilisation by a male.

There are some beetles which can reproduce without the collaboration of both sexes – the female simply produces offspring from unfertilised eggs. This kind of reproduction (known as parthenogenesis) is not a common occurrence among beetles. It is more frequently encountered with some other groups such as stick insects, aphids and bees.

Beetles develop through complete metamorphosis – the typical lifecycle consists of four basic forms: egg, larva, pupa and adult. The wonder of metamorphosis is

The typical mating position of weevils (Curculionidae) and many other beetles; with the smaller male riding on the back of the female.

one of the most fascinating events an entomologist can observe. Although modern science knows a great deal about this process, it is still a miraculous event.

Eggs

Beetle eggs are generally quite simple; most of them are ovoid or round, like tiny balls and usually creamy coloured or translucent. However, the full spectrum is huge – there are eggs of every possible shape and colour.

Some species – certain dung beetles (Scarabaeidae: Scarabaeinae) for instance – lay only a single egg while others may produce thousands at a time. The smallest numbers of eggs are laid by those species that care for their offspring.

Although only few beetles care for their eggs once they are laid, many species prepare a suitable place, where they can leave them safely and the emerging larvae can readily find food. In this, beetles show true ingenuity. Some disguise their eggs with a coating of excrement, which may contain a 'starting culture' of microscopic symbionts, necessary for newly born larva to process its food. Others build elaborate burrows for egg-laying and pack them with specially prepared food for their progeny.

But there are many species of beetles that simply drop their eggs amidst plentiful food supplies or scatter them around 'carelessly' on the ground and let the hatching larvae fend for themselves the best way they can.

In temperate environments egg laying often occurs towards the end of summer and the larvae hatch the following spring. When the time comes to emerge, the larva bursts the skin of the egg, known as the chorion. Some beetle larvae are equipped with special tools for the purpose of tearing the chorion open. These organs are hardened spikes, ridges or tooth-like

The eggs of the common spotted ladybird, *Harmonia conformis* (Coccinellidae). Photo: O Kelly

processes, which later – when they are no longer needed – are shed at the first moult.

The larva

Larvae don't resemble their parent beetles at all. The appearance of the various groups differs so much that it is virtually impossible to conjure up a typical form. We can't even go by the number of legs – many species have the usual three pairs, but just as many have no legs at all.

But there are a few characteristics that mark a beetle larva and set it apart from the larvae of other insects. Its head is usually well developed and sclerotised; it has chewing mouthparts; three thoracic segments – which sometimes are not too easy to recognise – and 8–10 abdominal segments. The second last abdominal segment may have a pair of processes, called urogomphi. These long and slender organs are somewhat similar in appearance to the cerci of insects such as earwigs (Dermaptera). However, no adult beetles have urogomphi or cerci and therefore it may seem strange that some beetle larvae do have these organs.

The legs of the larvae can be as diverse than those of the adult beetles. Aquatic species have natorial (swimming) legs, while

Some beetle larvae

A 'curl-grub' type larva of a stag beetle (Lucanidae), typical of the Scarabaeoidea.

The carpet beetle (Dermestidae) larva is free-living and strongly sclerotised.

The predaceous larva of a diving beetle (Dytiscidae) has a breathing siphon at the tip of its abdomen.

The campodeiform, predatory larvae of the Carabidae are fast moving and strongly sclerotised.

the legs of the larvae which have to dig their way into food, such as those of the hide beetles (Dermestidae), are of typically fossorial (digging) form.

Many beetle larvae have to move quite frequently on open ground or on the vegetation, therefore they have to be reasonably agile. These usually have six legs, often equipped with supplementary structures, such as claws, tufts and bristles. Those, which live in narrow passages bored and dug inside plants, can do without legs. They move with a wriggling motion, aided by folds on the dorsal and ventral sides of their bodies.

Highly mobile, predatory larvae with prognathous heads, long legs and paired urogomphi – like those of ground beetles (Carabidae) and rove beetles (Staphylinidae) are known as campodeiform. Larvae that are less active and have a cylindrical body shape with or without short urogomphi and short legs, like those of the leaf beetles (Chrysomelidae) are known as eruciform. Perhaps the best known are the so called 'curl-grubs', the plump, C-shaped, long-legged

This longicorn larva (Cerambycidae), could have remained for years in this piece of timber after it was felled and used in building.

The common 'mealworms' that are often used as pet food, are actually the larvae of tenebrionid beetles, *Tenebrio molitor* (Tenebrionidae), which have a large number of instars.

scarabaeiform beetle larvae. As their collective name reveals, they are the immature forms of the scarabs and scarab-like beetles, including the stag beetles (Lucanidae). Larvae without legs are called apodus; they usually live in rotting wood, in the soil or inside live plants, such as those of many weevils (Curculionoidea).

The skin of most beetle larvae is reasonably flexible. When it is stretched to its limit by the growing animal it has to give – the old exoskeleton splits open and the larva leaves through the opening, covered by a new soft, flexible skin, thus allowing its owner to expand as much as necessary. In time, the new skin also hardens a little but, meanwhile, the larva keeps growing until its skin can't stretch any further. Then it moults again. The process of growing and moulting repeats itself again and again.

The larvae of some beetles may only moult twice before reaching their maximum size and the final stage before pupating. Others, like some darkling beetles (Tenebrionidae), moult 10–16 times.

The larvae of some beetles simply keep growing between moults, without any conspicuous changes, apart from increasing in size. But some undergo major transformations; their appearance and life style can dramatically change in each larval stage – e.g. blister beetles (Meloidae).

The majority of beetles spend most of their lives as larvae. Those that live in quickly changing and deteriorating environments, like in a decaying carcass for instance, have to grow and change into adults quickly, before the cadaver dries up or even disappears, due to the voracious appetites of some competing life forms. The larvae of carrion beetles (Silphidae), therefore, have very short larval periods. Others, like many leaf beetles (Chrysomelidae), don't have much time to waste either, because their food plants may wilt and wither as their season advances, leaving them without suitable fodder. On the other hand, those species that live in heavy timber have all the time in the world. For example, the larva of the tiny death-watch beetle (Anobiidae) can afford to spend several years within a heavy timber beam before pupating. Usually, dry wood with low nutrient contents slows down the development of larvae. Longicorns (Cerambycidae) sometimes emerge from timber in houses, which were built decades earlier.

Some beetle pupae

Longicorn beetle (Cerambycidae).

Museum beetle (Dermestidae).

Weevil (Curculionidae).

Ladybird (Coccinellidae) pupa, attached to the underside of a leaf.

The pupa

Once the larva reaches the last stage in its development, its muscles and organs begin to transform. The larva often changes colour and its posture and shape begins to alter. The insect is approaching its next stage in life: the pupa.

Pupation is often preceded with a period of inactivity and the larva hides in a quiet, secluded and safe place where it remains. Many beetles build a special pupal cell or nest before beginning to pupate. These can be made from larval excrement, soil particles or debris found in the vicinity. It is usually completed from the inside, thus encapsulating the larva. Some species that live in decaying wood or under bark build cradle-like nests or hollow out special pupating chambers inside the timber, while others prepare underground cells in the soil. However, a great many species don't do any of this. They just find a suitable place and start to pupate.

As the larva's body shape alters, it begins to look like the adult beetle. Its exoskeleton thickens and often takes on the colour of

stained and polished wood, but sometimes retains the waxy appearance of the larva. With the pupae of some species, the articulated antennae, the legs and the wings are clearly visible but folded against the body. In others, however, none of the body parts is visible externally and the pupa has the appearance of a wrapped or encased mummy.

Most beetle pupae are immobile. Some, however, can react to stimulation, at least with a wriggle of the abdomen. Pupae are sensitive, often the slightest disturbance can harm or even kill them – as any coleopterist who has tried to rear beetles would know. Usually they react badly to changes in humidity and temperature, to physical contact with other organisms – including rough handling by humans. Even a small injury can cause deformities or more serious organ malfunctions in the developing beetle within the pupa. Therefore, it is important for their survival to find or build a suitable, well-protected hide, where they can remain undisturbed.

Emergence of the adult

How long does it take for the larva within the pupa to change into an adult beetle? Some rove beetles (Staphylinidae) may emerge from their pupae after only a few days but others may need over a year to complete their development. Beetles of the temperate zones may pupate at the end of summer, survive the winter as pupae and the adults emerge only next year at spring or summer. Tropical species may develop quicker, but still could spend months as pupae.

When the adult beetle – also known as the imago – emerges from the pupa, the process of change is just about complete. The freshly emerged imagos of some species

The newly emerged adult (or imago) of a longhorn (*Agrianome spinicollis)* is soft and colourless (top) until its exoskeleton hardens and its colours develop (bottom). Photo: G Hangay

may be a little soft and even colourless for a short while but their exoskeletons darken and harden rapidly. Others, like some ladybirds (Coccinellidae), may take several months to acquire their full colour.

Not all beetles dive into 'action' immediately after emerging from the pupa. Many stay dormant within the pupal cell or nest for quite a long time, almost as if hesitating: is it worth leaving the relative safety of their birthplace? Nevertheless, the time comes sooner or later, and the beetle must come out of its hiding place to multiply and disperse.

Lifecyle of the common spotted ladybird

The common spotted ladybird *Harmonia conformis* lays its eggs in small clusters on the undersides of leaves. The newly hatched larvae are very mobile and soon disperse, looking for food.

The larva – also known as an instar – goes through four moults in which it casts off its old skin, or exoskeleton, and grows a new one to accomodate its increasing size. The first instar resembles an ant, not only by its appearance but also by its fast movements. During the following two stages, the instar has two yellow bands on its abdomen and becomes much more slow moving. It consumes large amounts of aphids and other small insects, most of which lack any kind of defence or the ability to escape. The growing ladybird larva uses its crochets – abdominal proleg-like processes – to help it move and also to hold onto a surface, while it uses its legs to grab hold of prey.

Once the larva has built up its fat reserves and is fully grown (12 mm) it is ready to pupate. It searches for a suitable place, usually on a leaf surface near the stem tip, where it rests for a day. It then fastens itself to the leaf by its crochets and begin to moult the last time.

After this last moulting, the larva becomes a pupa, safely anchored to the leaf by its crochets. The pupal stage lasts about eight days, after which the imago emerges.

Adults usually remain in the vicinity of their birthplace, although they are capable of flying relatively long distances. Their natural life span is one or two months, but late autumn generations sometimes overwinter and survive until next season.

eggs.

larva.

pupa.

adult.

Photos: O Kelly

Adult dimorphism

The adult males and females usually don't look the same, although the external differences of the sexes are not always obvious; with some species they are practically undetectable by the naked eye. But there are many groups of beetles that exhibit sexual dimorphism – the appearance of the males is so different from that of the females that they appear to be different species.

The most conspicuous examples of dimorphism can be found among stag beetles (Lucanidae) and rhinoceros or elephant beetles (Scarabaeidae: Dynastinae). The males of stag beetles often carry enormously enlarged mandibles and most of them are larger than the modest-looking, 'antler-less' females. The Australian male elephant beetle, *Xylotrupes ulysses australicus*, usually has a large horn on its head and conspicuous pronotal processes, which make him look like a scaled-down version of a prehistoric monster. His female counterparts are usually smaller and without such weaponry.

But those formidable looking instruments are not always weapons, as quite a few heavily horned species don't ever use them in combat nor self-defence. They are simply secondary sexual characteristics, advertising their owner's potency as a male. They may also indicate the level of physical strength and endurance.

Polymorphism

The size of particular beetle can be misleading, because a small male compared to a large female could suggest that the males of that particular species are smaller

The horned male (left) and the hornless female (right) of the elephant beetle, *Xylotrupes ulysses australicus* (Scarabaeidae), look very different.

The stag beetle, *Prosopocoilus torrensis* (Lucanidae) spends only a small fraction of its life as an adult.

than females. In reality it is quite possible that a large female dwarfs a small male, but the opposite is also quite possible. Size varies greatly, even within the same population of some species.

Individuals of the same species, even of the same gender, never look exactly the same. This variation of size and appearance within the same species and gender is known as polymorphism.

Longevity

Many people see an adult insect – a beetle for instance – as something quite different from its less-developed form, the larva or the pupa, and are under the impression that insects don't live long. They see a mayfly (Ephemeroptera) emerge and die within a few hours; they know that cicadas don't live much longer than a few weeks. But the adult form of an insect is only the last stage of a relatively long, often hidden larval life, spent underground or under water, inside rotting wood or live plants or a multitude of other places. However, before metamorphosing into its adult form, a mayfly spends one to three years in an aquatic environment, while a chirping cicada, which may die in a few days, is the same individual animal that has sucked the sap of roots underground for several years.

So, is a beetle's life short or long? Many adult beetles live longer than a year or two and some larger species could reach the ripe old age of 10 or even 12 years. However, many of the larger longicorns (Cerambycidae) and stag beetles (Lucanidae) which emerge in November or early December hardly ever live past January or February, having spent the first three to eight years of their cryptic lives inside a tree trunk. Most Australian Christmas beetles

(*Anoplognathus* spp.) have even shorter adult lives – only a couple of weeks or less, and there are countless species where the adults live only for a few days, just enough time to mate, lay eggs and die.

Some beetles will live longer in captivity (if looked after by conscientious and knowledgeable keepers) than in the wild, mainly because of the availability of good food supplies, perfect living conditions and the lack of natural enemies.

We also should consider the small size of insects, compared with that of the higher animals. As a rule of thumb, the lives of small animals are shorter than that of the larger ones. But insects – especially beetles – don't go by this 'rule'. Some of the larger Australian beetles – still very much lightweights in the animal kingdom – weigh no more than 12 or 13 g, yet they may live for several years or more.

In the temperate zone, where winters are cooler, some beetles hibernate and start afresh in the spring. Predators, such as the adults of some species of the ground beetles (Carabidae) live for two to three years in nature and probably longer in captivity. Pollen and nectar feeders, like many of the beautiful rose chafers (Cetoniinae) and jewel beetles (Buprestidae) simply starve to death when the flowers die on which they feed. Their adult lives are usually quite short unless they are not too fussy and can switch from one flower to another. Ladybirds (Coccinellidae) live for about a year or two. They, just like many other beetle species, can survive the cold climate winters by hiding under bark or thick moss. Peculiarly, many tropical species are shorter-lived, compared with those that live under much harsher climatic conditions.

Phalacrognathus muelleri (Lucanidae).

Food and survival

The huge number of species, occupying so many niches in nature, utilise many different resources – there are not too many things that some beetle somewhere will not eat. In many cases, however, the diet of the larva is different from that of the adult.

Beetles can be grouped according to the food they eat. They may be carnivorous (meat eaters), phytophagous (plant eaters or herbivorous) or omnivorous (meat and plant eaters). There are many other sub-categories within these groups, according to the more specific food eaten by certain groups.

The plant-eating beetles are fussier than most – they often specialise on certain plants, sometimes even only on specific parts of the plants. Beetles in decaying tree trunks often depend on microscopic fungi in the timber, while others prefer very dry, thin branches of fallen trees.

The majority of herbivores eat fresh, green foliage but many live on dried plant matter, including the many kinds of stored products of humans. Some plants that are otherwise poisonous are the most favoured foods for certain beetles – such as dry tobacco for the cigarette beetle, *Lasioderma serricorne* (Anobiidae). Nicotine is deadly for most insects, while the cigarette beetle can happily live on dry tobacco. Some minute beetles can thrive even in the hottest chilli and curry powders.

Carnivorous ground beetles (Carabidae) and rove beetles (Staphylinidae), as well as members of some other predatory families, will hunt and eat other arthropods and small animals such as earthworms, slugs and snails. Larger species can also tackle small vertebrate animals. For example, the Australian ground beetle *Catadromus latro* will prey on tiny frogs, while the predaceous diving beetles of the genus *Dytiscus* may tackle small fish, tadpoles and small water-newts.

The leaf beetles (Chrysomelidae) are gregarious plant eaters.

This ground beetle (Carabidae) is a worm-eating carnivore.

Decaying organic matter is a primary diet for many species. This can range from excrement, which is consumed by coprophagous (dung-eating) species such as the dung beetles (Scarabaeidae), to dead animals, which are eaten by necrophagous (carrion-eating) species such the carrion beetles (Silphidae).

However, specialisation is quite common as various groups of dung beetles have strong preferences to particular sorts of dung. For example those which thrive happily in cowpats may not go near horse dung – and vice versa. Most Australian endemic dung beetles favour the droppings of marsupials. Some necrophagous beetles prefer the cadavers of large animals, while others wouldn't touch anything larger than a mouse or a small bird. Members of the family Trogidae mostly feed on the desiccated carcasses of larger mammals.

Members of one peculiar group of beetles are associated with ants. They are known as myrmecophiles or ant-lovers. These species – as many as 3000 or more worldwide – belong to a number of families but they all share one important characteristic – they live in the nests of ants. Some are predators, preying on the ants within their homes, while some hunt parasitic mites that live on the ants. Others are more humble and eat the refuse and debris found in ant nests. But the most interesting associations are those in which the beetles exude secretions, which are favoured by the ants. In exchange for this delicacy, the ants feed the beetles and rear their larvae.

Termites are also hosts to a number of beetle species, called termitophiles, or termite-lovers. These beetles obtain their food in a more or less similar manner to myrmecophiles.

This ferocious aquatic beetle, a predatory dytiscid, can ambush an equally fearsome, predaceous water scorpion and make a meal of it.

One of the largest termite-loving beetles in Australia is the 6-mm-long *Megaxenus termitophilus* (Aderidae), which is often seen on the outside of termite mounds in north Queensland rainforests.

This weevil (Curculionidae) is using the chewing mandibles at the tip of its rostrum to dig holes for its eggs.

A few beetles live as ectoparasites on mammals. Rove beetles, belonging to the staphylinid tribe Amblyopinini are known to be parasitic on rats in Tasmania. Some beetles, which were thought to be parasites on various small mammals, have turned out to be predators of mites and other small organisms living in the animal's fur. In Australia, dung beetles of the genus *Onthophagus* (Scarabaeidae: Scarabaeinae) frequently cling to the fur of macropods, near their cloaca. They are not true parasites because they feed on the dung of these animals. Why does the beetle attach itself so near to the source of its dinner? More than likely it prefers food as moist as possible in this most arid of continents!

Less disgusting, albeit equally bizarre are the eating habits and food preferences of those beetles which grow their own supplies. Ambrosia beetles (Curculionidae: Scolytinae, Platypodinae) live on 'ambrosia' – which is actually a kind of fungus cultivated by them. Ambrosia beetles – as well as species from a number of other families – bore into timber and develop complex systems of tunnels and chambers, where they farm the fungi. Spores are spread and 'planted' by the beetles into newly tunnelled passages, thus securing continuous, ample food supplies for themselves and their offspring.

Right tools for the job

With so many different kinds of food to consume, beetles have developed a vast array of methods and 'tools' to deal with them. Their chewing mouths are often specialised. For example, the heads of weevils (Curculionidae) evolved into an elongated form and their mouths are positioned at the ends of their long rostrums in order to be able to dig deep into plant tissues. The purpose of this is not solely for obtaining food, but also to prepare suitable depositories for their eggs.

Digestion

Some beetles don't chew their food – they are liquid feeders and employ a peculiar method for preparing their food, known as extraoral digestion. They use their mandibles to capture and kill or de-mobilise their prey and then introduce some digestive juice to

them and lick up the resulting goo. Not a nice way of eating, but it is very effective!

The digestive tract of beetles has developed differently in different species. Some of those that imbibe their nourishment in roughly cut particles, or feed on substances which are difficult to digest, have developed a kind of crop, in which the particles of food undergo a pre-digestive process before passing further into the alimentary canal. This process also includes the grinding of food particles by the sclerotised ridges and spines of the crop's interior.

Digestion sometimes needs a bit of help from other organisms. Certain substances could not be digested by some beetles without the assistance of microbes living in their digestive tract. These organisms are known as symbiotes, because they live in a symbiotic relationship with the beetles.

Defence against predators

One of the main worries of most living organisms is to be eaten by another organism – just about anything that lives could be someone else's dinner. Even most of the phytophagous insects, which feed on live plants could be considered 'predators' as they find and eat living organisms (mainly plants, though) – or at least parts of them. Plants have developed all manners of defences – mainly chemical ones and not always successful ones – against such attacks. Animals, being mobile, can run away when threatened or dig their heels in and put up a fight if necessary. Many beetles are armed with formidable mandibles, spiky legs and sharp-edged pronotums with which they can bite, pinch, stab and cut if necessary. Fighting back or fleeing are very effective, instinctive anti-predator responses, but they are not quite 'cost-effective'. The energy spent on fighting, jumping, running, swimming or flying from danger is costly – to replenish reserves after such episodes requires extra resources, such as food and water. To avoid this 'out of budget' expense is perhaps the main reason why animals, through slow, evolutionary processes, have developed different lines of defence which are much more passive and consequently much less energy consuming. Most of these passive methods of defence rely on adaptive colouration, form and behaviour. Examples of these various kinds of active and passive defences can be found everywhere in the animal kingdom and beetles are no exceptions.

Concealing (cryptic) garbs of many insects prove to be very effective to avoid the attention of predators. Among the insects, beetles too have their fair share of camouflaged species. Their camouflage doesn't stop at cryptic colours. Many beetle larvae cover themselves with bits and pieces of debris, sometimes even with their own excrement in order to blend in with their surroundings. Camouflaged beetles – just like any other such insects – usually don't flee from enemies. Their immobility, coupled with cryptic colouring, is their best defence.

There are no fewer than five individual beetles (Tenebrionidae) on the tip of this dead branch, one of the best examples of cryptic colouration in beetles. Photo: O Kelly

A well-camouflaged, ground-dwelling longhorn beetle (Cerambycidae).

When threatened, ceratocanthine beetles can roll up into a very hard, defensive ball. Drawing: SP Kim, CSIRO

Immobility by itself is also a kind of self-defence, a passive way of deterring a predator – but it doesn't necessarily work every time! Many species simply feign death in order to deceive predators, which react more readily to moving prey. This phenomenon is known as thanatosis and it is very effective if the beetle lives higher than ground level, as it immediately would fall down and with a little luck, disappear in the vegetation or leaf litter below. This often frustrates coleopterists! Even brightly coloured specimens are hard to spot if they remain immobile in the undergrowth.

Some species roll into a ball; the most notable amongst these are the members of the Clambidae family. These very small (0.5–1.5 mm) beetles, when disturbed, can fold their heads and pronotum downwards, forming an almost perfect ball. They can fall and roll out of sight within a split second. Many other beetles simply tuck their legs against their compact, rounded bodies, taking up the appearance of a seed, small lump of dirt or pebble. Some others behave as if they are suffering from a cramp – they stretch out with legs in unnatural poses and their entire body becomes rigid. They hold this stance even if moved about, although some do it only for a certain time, and then suddenly come to life again to make a swift getaway. The art of this kind of defence is to 'know' when to do this!

Beetles can also combine passive defence with chemical 'weaponry'. They exude a foul smelling liquid from their anal glands, which repels fussy predators. Both rove beetles (Staphylinidae) and darkling beetles (Tenebrionidae) are known to do this also. A great number of ground beetles (Carabidae) also use repulsive secretions as a form of defence, but most of them are far from passive creatures; they can also bite viciously if cornered! In defending themselves, great water beetles of the genus *Dytiscus* (Dytiscidae) may discharge a milky substance from their glands found on the sides of their prothorax. Whirligig beetles (Gyrinidae) do the same from glands on their abdominal segments.

Other insects have gone one step further and have developed some very potent forms of defence – their body tissues contain substances that make them disagreeable to predators. Some are downright poisonous, others are distasteful, bitter or acidy and cause malfunctions in the digestive system of a predator. This mode of defence is useful only against predators that are capable of learning. Most vertebrate animals learn quickly which insect can be eaten and which ones cannot. A poisonous meal will be regurgitated and well remembered for future reference! This 'teaching method' of course will cost the life of the 'teacher' but undoubtedly, it will well serve its brethren as long as the episode is stored in the memory of the predator. To ensure that it will recognise another specimen of the same poisonous nature and leave it alone, the insect must have some conspicuous colours to remember it by. These are usually vivid, outstanding colours or colour combinations, known as aposematic colouration.

Potential predators of this aposematic leaf beetle, *Phyllocharis hilaris* (Chrysomelidae), have learned to avoid it.

Often the most beautiful, striking insects are the poisonous ones. Or is this just an illusion? Sometimes it is. Some insects through millennia of evolution 'learned' to mimic each other. Palatable species, known as mimics, mimic unpalatable species, known as models, by developing resemblances, more often by colours but sometimes in forms too.

During the course of evolution, many species with effective chemical defences have come to resemble each other. Hymenopterans provide the best examples for this: bees, wasps, hornets and other 'dangerous' groups have black and yellow stripes. This became a clear danger sign to many predators: it means that anything with these colour combinations is noxious and is best to avoid. To resemble each other provides an advantage to these noxious species because it reduces the number of casualties while predators learn to avoid them. This kind of mimicry is named after its discoverer, the German naturalist, Fritz Müller. Insects which are not actually unpalatable have also evolved to mimic these dangerous groups or even individual species. Such mimicry is called Batesian, after the naturalist Henry Bates, who first extensively documented this phenomenon in South America. Often a very unpalatable or dangerous model will be mimicked by many species of insects across various orders and families, in groups known as Batesian 'chains'.

Temperature control

Insects are 'cold blooded', which means that their body temperature is the same as that of their environment. At high temperature, their heart may pump faster – some species can have a 140 beat/minute heartbeat, which could send a human to

A lycid beetle (Lycidae), the unpalatable model in one of the longest Batesian mimicry chains in Australian beetles.

A jewel beetle (Buprestidae) mimicking the lycid beetle. There are tens of mimic species across at least three insect orders, but especially among the beetles.

An oil or blister beetle (Meloidae) mimicking the lycid beetle.

Even this oecophorid moth (Oecophoridae) is a lycid mimic.

the threshold of heart attack. On the other hand, in cold environment, a hibernating beetle's heart may produce no more than one beat per hour.

Freezing is deadly for most insects. Because they can't generate their own body heat (except for some wasps and bees), the relatively high water content of their tissues freeze. The frozen water molecules form sharp ice crystals around tiny foreign particles within their bodies. The clusters of ice expand and rapture body cells, killing the insects.

Insects living in temperate or sub-arctic environments which have to endure harsh winters, have developed defences against

below freezing temperatures by producing glycerol – a kind of antifreeze, which prevents the freezing of body fluids. At the same time the cells actively eliminate all waste products or other foreign particles that an ice crystal might form around. This two-step process, called supercooling, allows body fluids to remain liquid far below the normal freezing point of water.

Other beetles have 'learned' how to isolate ice crystals between cells so that they cannot cause any harm. This method of defence allows the insects to withstand a limited amount of freezing, sufficient enough for those which have to live through the winter in the temperate zone. Supercooling is more efficient in the sub-polar environments, where winters bring extreme cold.

Can insects learn?

Beetles are capable of executing complex behavioural tasks, which indicates that they have well developed nervous systems. However, their actions are almost entirely innate. The complicated procedure to find a mate, copulate, deposit eggs, forage for food and generally, manage life without getting killed before reproduction takes place, is not a simple business. Yet most beetles can do all this, quite successfully, just by following their instinct. Just as well, because the capacity for learning of an individual beetle is very slight.

Researchers have carried out numerous experiments to investigate whether beetles can learn new modes of behaviour, develop responses to certain requirements and, above all, retain any of their newly acquired 'knowledge'.

The experiments have resulted in some very interesting findings. For example, the great predatory water beetles (Dytiscidae) could learn a yes/no response but they were unable to remember it for long. Experiments with both the larval and the adult stages of the mealworm, *Tenebrio molitor* (Tenebrionidae), showed much more. Larvae were trained to walk a narrow corridor, which lead to a 'T' junction. Here the larvae had a choice – they could go either left or right. If they turned right, they got to a breeding jar, with pleasant conditions and food. If they turned to the left, they had to repeat the run from the start. This rather simple training brought results. After a certain number of runs a certain number of larvae 'learned' to turn right instead of left.

The experiment was carried out with adult beetles too, with more or less the same result. But what followed, was truly interesting. First, the 'trained' larvae, those that knew that turning right was 'good', were allowed to pupate and change into adult beetles. Now these freshly emerged beetles were trained to learn the same task, but the other way around. They had to choose left to reach the comforts of the breeding jar. It turned out that these beetles, which in their larval form received training in the opposite sense, were rather slow learners, as a matter of fact slower than those which received no training at all during their larval lives. It seemed that the 'knowledge' that they had obtained as larvae somewhat affected their adult behaviour too, almost as if they 'remembered' that turning left was the wrong choice.

Higher taxonomy

The following is a brief outline of the higher taxonomy of Coleoptera, which consists of four suborders and a number of superfamiles into which the familes are placed.

Suborder Archostemata

These living fossils are represented in Australia by one superfamily (Cupedoidea) with two small families.

Superfamily Cupedoidea

They are moderately large, elongated beetles, with visible notopleural sutures on the prothorax; their hind coxae are somewhat moveable although attached to metasternum; the wings have a peculiar venation (usually with a distinct apical cell) and on their abdomen five sternites are visible. Their tarsal segmentation is 5-5-5. The Australian species generally are clothed in scale-like setae. (See pages 46–47.)

Suborder Myxophaga

Beetles belonging to this suborder are minute (usually less than 1 mm), with visible notopleural sutures on the prothorax and with short, clubbed antennae.

Superfamily Sphaeriusoidea

The Sphaeriusoidea consists of a small number of species, divided into four families. It is represented in Australia by only one family: Sphaeriusidae. (See page 48.)

Suborder Adephaga

This suborder comprises of one superfamily (Caraboidea), several families and a relatively large number of genera and species, many of them highly specialised. They differ from the preceeding suborders by having rigidly fixed coxae and six abdominal ventrites.

Superfamily Caraboidea

The most distinctive feature of these beetles is that their first abdominal segment is divided by the hind coxae. Their antennae are usually thread-like, but sometimes bead-like, clubbed or even extraordinarily flattened (Carabidae: Paussini). Most beetles belonging to this superfamily are predaceous. Many of them are terrestrial, others are aquatic or semi-aquatic. (See pages 49–63.)

The carabid ground beetle, *Ametroglossus ater* (16 mm), from north-east coastal Queensland is an arboreal species but also roams the forest floor at night, hunting for invertebrates.

Suborder Polyphaga

This is the largest suborder of Coleoptera. The main unifying characteristics of these beetles are obscure and internal, but one visible feature is that the first abdominal segment is not divided by the hind coxae. The many families are, at present, grouped into the following superfamilies.

Superfamily Hydrophiloidea

This superfamily contains the aquatic or semi-aquatic Hydrophilidae and the terrestrial Histeridae. (See pages 64–66.)

Superfamily Staphylinoidea

Staphylinoidea are the rove beetles and their related families. Their procoxae are usually well pronounced and projecting; the metasternum usually is without median suture; and the elytra are often shortened exposing the abdomen at various degrees. (See pages 67–75.)

Superfamily Scarabaeoidea

The most prominent feature of the Scarabaeoidea (or Lamellicornia as they were known in earlier times) is their lamellate antennae. This is a highly developed organ, with the terminal segments expanded sideways, forming a club. This club consists of leaves (lamellae) which can be opened in a fan-like fashion or closed thightly to protect its delicate sensory surfaces.

Many scarabeaoids are relatively large, often brightly coloured and therefore they are quite conspicuous. On the other hand, the great majority of them are medium to small in size, mostly brown or black and lead cryptic lives. Many are of economic importance; some are serious pests of cultivated plants and forests, while others are beneficial to humans by processing the dung of cattle and of other introduced large mammals, thus improving pastures and reducing annoying fly populations.

The scarabaeoid larva is also distinctive by being C-shaped – commonly called 'curl grubs' – and having three pairs of well-developed legs. Their head is hypognathous with strong mandibles and a pair of three or four segmented antennae. Adults and larvae alike are adapted to burrowing. Adults, in certain stages in their lives dig into the soil, leaf litter, decaying wood and sometimes even in the accumulated sawdust of timber mills in order to lay their eggs. Coprophagous species excavate in and under dung and some burrow into carcasses. Most scarabaeoid larvae live in these habitats.

The scarabaeoid fauna of Australia is probably the best known of any other equivalent beetle group as many eminent coleopterists have chosen to research these fascinating beetles. Presently 314 genera and 2620 species are known in Australia. (See pages 76–101.)

The stag beetle *Aegus jansoni* (18 mm) belongs to the family Lucanidae, superfamily Scarabaeoidea. Members of this superfamily have highly developed lamellate antennae.

Superfamily Scirtoidea

These beetles are small- to medium-sized (1.8–11 mm), with a small pronotum and a reduced prosternum. They can compact themselves by folding their head under, resting tightly against the ventral side of the body. They usually can be found on vegetation near water. Some frequent flowers, others rotting vegetable matter. (See pages 102–104.)

Superfamily Dascilloidea

The two families of beetles (Dascillidae and Rhipiceridae) that belong to this superfamily look quite different. However, species of both families have similar type prothoracic interlocking device, open procoxal cavities, their prominent mandibles lack a distinct molar area, the coxae are conical and projecting tarsal segments have paired membranous ventral lobes. They are of moderate size; the length of their elongated body varies from 7.5 mm to 25 mm. (See pages 105–106.)

This *Athephylla* species (10 mm) is a firefly (Lampyridae) of north Queensland. It is a member of the large superfamily Elateroidea.

Superfamily Buprestoidea

Only one family, Buprestidae, belongs to this superfamily. These are the jewel beetles and are very different from all other beetles. Because their general shape is distinctive, most species are easily recognised as jewel beetles. (See pages 107–112.)

Superfamily Byrrhoidea

Beetles belonging to this superfamily are variable and it is difficult to give a short, description which fits all. They are small to medium sized, often pubescent beetles, some aquatic or sub-aquatic. (See pages 113–120.)

Superfamily Elateroidea

This large superfamily contains some well-known beetles, including the click beetles (Elateridae), fireflies (Lampyridae), net-winged (Lycidae) and soldier beetles (Cantharidae). In the past some of these groups belonged to other superfamilies but revisions during the last two decades have placed them into the Elateroidea.

The Australian fauna has eight families in this superfamily. Some of the familes have many species, while others have far fewer. One family, the Rhinorhipidae, is endemic to Australia and has only one described species.

The biology of these beetles is varied – some are predaceous, others are plant feeders, while the adults of many species don't seem to eat at all. Their larvae usually take a long time to develop, while adults have much shorter lives. The larvae of some of the plant feeders, such as those of the click beetles, may have economic significance, as they feed on the roots of some cultivated plants, thus causing damage. (See pages 121–131.)

Superfamily Bostrichoidea
Beetles in this group are usually small to medium in size, their body is elongate or ovoid and often somewhat cylindrical. The head is relatively small and in most families bent downward, the pronotum is often strongly convex with anterior opening (where the head joins it) facing downward. Pronotum often forms a hood (except in Nosodendridae and Dermestidae), that conceales the head from above. The elytra are often very convex. (See pages 132–139.)

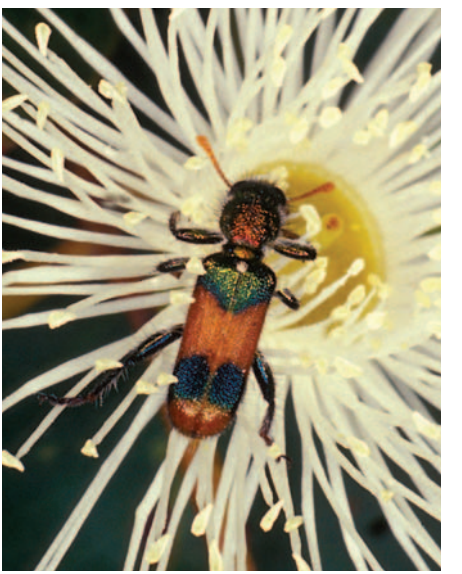
Superfamily Lymexyloidea
These are elongate, soft-bodied beetles, some with long, narrow elytra, while others have very short elytra and exposed wings, which are folded fan-wise over the ventral side of the abdomen. Males have very large eyes, meeting in the mid-line in front. This group represents an isolated lineage, having some affinities with Cleroidea.[4] Only one family (Lymexylidae) is known from Australia. (See page 140.)

Superfamily Cleroidea
The beetles in this superfamily are small to medium-sized. In the past, the Cleroidea in Australia included only the families Trogossitidae and Cleridae. However, the families Phycosecidae (formerly in the Cucujoidea), Melyridae (formerly in the Cantharoidea) and Acanthocnemidae have now been assigned to this superfamily. (See pages 141–146.)

Superfamily Cucujoidea
The beetle families in this superfamily are so diverse in appearance that it is rather difficult to summarise their common characteristics by which the non-specialist could recognise them as cucujoids.

They are generally small, some minute. Their antennae are filiform, thickened apically or with a club and never elbowed. The anterior coxae don't project and the lateral margin of the pronotum is distinct. The number of tarsal segments is important in the classification of Cucujoidea but they are often difficult to count as the basal segment is often very small, almost invisible without dissection under the microscope.

Worldwide, the Cucujoidea contains a large number of families of which 27 (since Languriidae was combined with Erotylidae) occur in Australia. The taxonomy of these beetles and of those which were recently re-assigned to other superfamilies is very complex and confusing to the non-specialist. During the last few years 104 genera and 400 species have been synonymised within the Australian Cucujoidea. Determination, even at the family level is quite difficult, mainly because of the lack of up-to-date literature, which would provide an overview



This beetle, *Eleale lepida,* from a north Queensland open forest belongs to the family Cleridae, in the superfamily Cleroidea.

of the entire subfamily. However, some families, such as Nitidulidae, Silvanidae, Passandridae, Cucujidae, Erotylidae, Coccinellidae, Latridiidae and a few others are not too difficult to recognise and are included in this book. Families, which are very poorly represented in Australia, whose occurrence is very restricted or are rare have not been included, as it is highly unlikely that the reader would come across any of these. (See pages 147–165.)

Superfamily Tenebrionoidea

This large superfamily now includes a number of families which were earlier classified as groups within the Cucujoidea. The largest family here is the Tenebrionidae or darkling beetles. Another family, now much larger than it was before, is the Zopheridae. Two other families, Monommatidae and Colydiidae, with hundreds of species worldwide, have been reassigned and incorporated into it. There are no monommatids on our continent, but the sum total of the Australian zopherid species has been increased by the addition of the hundred or so Australian species of Colydiidae. These beetles now form the subfamily Colydiinae within Zopheridae. (See pages 166–190.)

A chrysomelin leaf beetle belonging to the family Chrysomelidae. There are 24 described species of the genus *Phyllocharis* in Australia. Not much is known about their biology. This species (7 mm) was photographed in north Queensland.

Superfamily Chrysomeloidea

This is a large superfamily containing seven families with more then 56 000 described species worldwide. Only three families, Cerambycidae, Chrysomelidae and Megalopodidae represent the Chrysomeloidea in Australia, with about 4300 described species. The appearances of these families are so different from each other that it is difficult to describe some easily recognisable mutual characteristics, which would identify them as members of the same superfamily. However, one such characteristic is that all chrysomeloids have antennae inserted on the dorsal surface of the head. Most have 5-segmented tarsi, but the penultimate segment is very small and often completely concealed by the third segment. Thus the tarsi appear 4-segmented, known as pseudotetramerous tarsi. In Cassidinae the fourth segment is fused to the fifth or rarely both are completely absent. The head has two gular sutures and never produces into a rostrum, the metasternum has a transverse suture and the abdomen has five visible sternites. Other important characteristics, such as the male reproductive organs, can only be seen by dissection under a microscope. All Australian chrysomeloids are phytophagous. A few overseas species, however, feed on ants. (See pages 191–208.)

Superfamily Curculionoidea

This immense superfamily, the largest of any living organisms, contains the weevils. There are more than 66 000 described species worldwide, of which about 6500 occur in Australia. The actual number of species may be twice as much, if we consider the hitherto undiscovered and undescribed ones too. But even this may be a conservative estimate. Sir Guy Marshall, the most experienced authority on weevils of our time, thought that the world's curculionoid fauna may consists of 200 000 to 250 000, mostly undescribed, species.

The Australian fauna is especially diverse and rich, compared with other geographical regions of the world. As may be expected with such a huge and diverse group, the taxonomy of Curculionoidea is far from being thoroughly researched. The most important, albeit unfinished monographs were created by Elwood C Zimmerman and, at present, his *Australian Weevils*[5] is the most up-to-date, detailed work of parts of our curculionoid fauna. However, because of its uncomplete state, we continue to use the Lawrence and Newton system, with eight recognised families.[6]

The complexity and the extent of our fauna make it impossible to mention every weevil family that occurs in Australia. Instead, a few examples from the six most significant families are described on pages 209–222.

Weevils form the largest family of living organisms in the world. About 6500 named species of curculionoids are known from Australia.

Family descriptions

Cupedidae

Reticulated beetles

- antennae longer than head and prothorax together
- antennal insertions dorsal and almost adjacent
- labrum free and visible
- ventral side of prothorax with deep grooves for retention of legs
- tibiae without spurs
- tarsal formula: 5-5-5, tarsal segment 4 ventrally lobed

Reticulated beetles mainly inhabit forests, but also occur in open woodland and arid pastureland as well, from north Queensland to Western Australia and Tasmania.[7] They are not common anywhere and quite rare in collections. At present there are only six described species divided into two genera in Australia.

Little is known about their habits except that the larva lives in firm, dry, but fungi-infested, decaying wood and the adults can also be found in the same environment. They may be pollen feeders, judging by the grains of pollen found in the gut of one species and the flower-visiting habits of another. They may be seen flying around infested timber on sunny days and some species are attracted to artificial light at night. The males of some species get attracted to laundry detergents (bleach). It is suspected that these substances may act as female sex attractants.

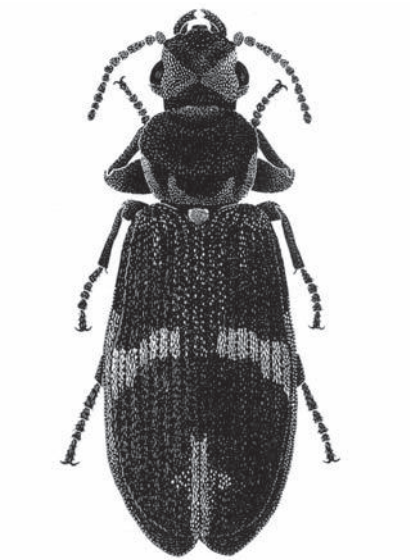
Distocupes varians (10 mm) is the only representative of this genus in Australia. It occurs in the coastal areas of eastern Queensland, in New South Wales, the Australian Capital Territory, Victoria and Tasmania. Photo: O Kelly

Ommatidae

Ommatid beetles

- antennal insertions lateral and well separated
- antennae shorter than head and prothorax together
- labrum not distinct
- venter of prothorax without deep grooves for retention of legs
- simple fourth tarsal segment
- tarsal formula: 5-5-5

Ommatid beetles are rather similar in appearance to cupedids, although some species may have a metallic (bronze) sheen. At present only four Australian species are known. Before 1995 they belonged to the family Cupedidae. Ommatid beetles occur in western New South Wales, Victoria and South Australia in dense forests but, just like the cupedids, they also live in pastureland and in drier country, where they probably develop in subterranean, decaying, fungus-ridden wood, such as roots or fallen trees. Ommatids are rarely seen, most probably because of their cryptic life styles. They are sometimes captured by flight intercept traps or purely by chance.



Omma masteri (subfamily Ommatinae) is a typical ommatid beetle. Drawing: B P Moore

Sphaeriusidae

Minute bog beetles

- small (about 0.8 mm long), shiny, dark brown or black, ovoid, pill-like beetles
- hairless, strongly convex on the dorsal side and almost flat on the ventral side
- only three abdominal sternites are visible ventrally
- short, 11-segmented, clubbed antennae, with longish bristles at the ends

Minute bog beetles can be found in wet mud, gravel, sand and under submerged logs and stones at the edges of streams and in boggy environments. They have piercing mouthparts and probably feed on algae. Because of their minuscule size and cryptic life style, they are difficult to spot, although they may be more common and more widely spread than one would think. They are rare in collections. The best method of finding them is to stir portions of riverside shingle into a pan of water and collect the beetles as they float to the surface.

Only two species occur in Australia: *Sphaerius ovensensis* in Victoria and New South Wales and *Sphaerius coenensis* in north Queensland.

The tiny *Sphaerius ovensensis* lives in fine shingle at the edges of streams in Victoria and New South Wales. The adults can spend considerable time under water as they store air taken from the surface under their elytra. Drawing: F Nanninga, CSIRO

Gyrinidae

Whirligig beetles

- boat-shaped, shiny, dark blue or olive-green, aquatic beetles, 4–18 mm in length
- entire body streamlined, antennae short (about as long as eye)
- eyes completely divided into upper and lower segments
- fore legs are long and modified for grasping prey, mid and hind legs are short, flattened , fringed with flattened swimming hairs

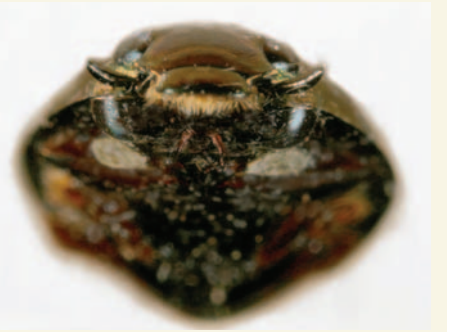
Whirligig beetles occur in clean, fresh water in most parts of Australia. The family is represented by four genera and 19 species in Australia. The gyrinid body is perfectly 'streamlined' for moving quickly in water, especially on its surface. They swim gregariously in continuous tight circles, whirling around on the surface. When disturbed, they quickly dive into deeper water. Whirligigs occur in still and moving water. They often congregate in large numbers; sometimes more than one species can be found in such groups.

Macrogyrus elongatus (subfamily Gyrininae) is about 8 mm in length. Whirligigs are the only beetles that make use of the surface tension of water for support.

The behaviour of whirligigs is distinctive as well as their appearance. They are mostly active during the day.

Extrasensory perception?

Whirligigs often capture other insects when they fall into the water. Although they have 'four' eyes, they often can't see a potential meal, because the surface of the water is in their 'blind spot' – aligned exactly with the division between the upper and the lower sections of their eyes. Yet, they hardly ever miss a meal! How? Their antennae help them locate the prey, helplessly struggling on the surface of the water. The whirligig has a special organ (Johnston's organ) located in the enlarged second segment of each antenna, which detects the miniature waves created by the struggling prey. This organ is also useful in more peaceful tasks, such as navigating without bumping into anything. A moving whirligig creates tiny waves which bounce back from any obstacles in its vicinity. The organ detects these echo-like waves, thus guiding the swimming beetle on a collision-proof course.[8]



The 'four' eyes of the whirligig.

A whirligig beetle makes a meal of a dead fish.

Dineutus australis (subfamily Gyrininae) is known from most parts of Australia. It can breathe under water from an air bubble carried at its rear.

The eyes of gyrinids are divided into upper and lower sections, enabling them to see clearly above water and underwater, possibly at the same time. Their antennae are short and stout, as are their mid and hind legs, which are flattened and equipped with long, stiff hair, adapted for swimming. Gyrinids are mostly carnivorous scavengers and predators – they use their long fore legs for grasping prey.

The larvae are also aquatic, with feather-like gills. They spend most of their life on the bottom of streams and ponds, hunting soft-bodied prey, such as water-dwelling worms and the larvae of other aquatic insects. The last instar larva, having already developed functional spiracles, leaves the water to pupate on land, just above the water surface.

Haliplidae

Crawling water beetles

- body strongly convex and somewhat broadly boat-shaped, with the striated elytra tapering into a point at the posterior, 1.7–5 mm in length
- base colour is yellowish or light brown, the elytra's striae are marked with punctures and darker pigmentation, forming prominent patterns
- hind coxae are enlarged, forming plates which conceal the basal abdominal segments and hind femora, but legs not flattened for swimming
- antennae short (less than width of head) with 11 segments
- scutellum is not visible
- three sternites can be seen on the ventral side of the abdomen, first three present but concealed by coxal plates

Crawling water beetles feed mainly on algae, although some species may be carnivorous. They can be found among aquatic vegetation in ponds, lakes and slow-flowing streams. They collect air from the surface and store it under their elytra and their large metacoxal plates. This enables them to remain underwater for long periods of time.

Crawling water beetles are not the best of swimmers. They crawl rather than swim and can move about on dry land as well. They are also good flyers and sometimes are attracted to lights at night. Their larvae are predaceous, fully aquatic and absorb oxygen from the water through their skin and gill-like organs. The final instar leaves the water to pupate on dry land, near the water's edge. Only one genus, *Haliplus*, with 14 species is known from Australia.

Haliplus testudo (5 mm) is one of the typical species of the only haliplid genus occurring in Australia.
Photo: J Gooderham & E Tsyrlin

Noteridae

Burrowing water beetles

- small, shiny, black or dark brown water beetles, 1.2–5.5 mm in length
- body shape resembles an upturned boat, with strongly convex dorsal surface
- scutellum is not visible
- prosternum, metaventrite and hind coxae joined together along strongly raised midline

Burrowing water beetles resemble the predaceous diving beetles (Dytiscidae) but their scutellum is not visible and they have a broad ventral median ridge. These beetles live in stagnant ponds and lakes, sometimes in slow-flowing streams. They frequent the shallows where they hunt for small invertebrate prey. Their larvae are perhaps scavengers, but very little is known of their biology. They have strong legs which allow them to move through the sediment and detritus at the bottom; hence their common name. Only four genera and six species occur in Australia.

Hydrocanthus australasiae (7 mm) is distributed over the coastal Wet Tropics of Queensland and the Northern Territory. Drawing: F Nanninga, CSIRO

Hygrobiidae

Screech beetles

- body stout, oval, not boat-shaped, 8–11.5 mm in length
- eyes protruding, not truly streamlined
- tarsi longer than the tibiae and equipped with strong hairs adapted for swimming
- tarsal formula: 5-5-5

The most conspicuous characteristic of these beetles is the shape of their eyes which, unlike those of most other water beetles, are rather protruding. The predaceous adults and larvae live on the bottom of ponds and swamps, foraging for suitable prey. Adult beetles regularly ascend to the surface to take in air which they store under their elytra.

Larvae can take oxygen from the water with their gill filaments. The third instar has functional spiracles through which it can breathe air above the surface when it leaves the water to pupate on shore.

Adults can fly and occasionally are drawn to artificial lights at night. When stressed, they stridulate by rubbing the dorsal part of their abdomen against the elytra.

There is only one genus, *Hygrobia*, with four species in Australia.

A species of *Hygrobia* (7 mm), which is the only genus of Hygrobiidae occurring in Australia.
Photo: J Gooderham & E Tsyrlin

Dytiscidae

Predaceous diving beetles

- boat-shaped, dorsally and ventrally convex, 1.2–38 mm in length
- mostly black, brown or dark olive-green, some with lighter coloured marginal markings and/or patterns on prothorax and elytra
- antennae longer than width of head
- hind tarsi flattened, fringed with stout swimming hairs
- tarsal formula: 5-5-5

Dytiscids are very distinctive beetles. They inhabit ponds, lakes, water-filled ditches and all kinds of running and still waters. However, they prefer those with slower flow. They occur in heavily forested, mesic areas east of the Great Divide, but also in more arid regions of open woodland and pastureland in western New South Wales, Victoria and South Australia.

Hydaticus parallelus (subfamily Dytiscinae) (10 mm) is a relatively common species, found in the eastern parts of Queensland and New South Wales.

As their common name indicates, both adult and larva are predaceous. They hunt a variety of prey including aquatic invertebrates and vertebrates such as tadpoles and small fish. Adults and larvae take air from the surface through their posterior spiracles, which in some cases are extended and siphon-like. Adults store this air in a cavity under their elytra and can remain underwater for extended periods, breathing from this reservoir. The third instar larva develops a full set of functional spiracles, leaves the water and pupates on shore. The Australian fauna consists of 43 genera and 215 species.

Recently a remarkable dytiscid fauna has been discovered in subterranean waters of the central and western deserts, with at least 80 species, many of which are blind and have other typical modifications of cave dwelling insects.[9] There is a also a terrestrial species, living in the wet leaf litter of the rainforests of North Queensland.

Predaceous diving beetles are good flyers – they usually take to the wing at dusk or during the night, looking for a mate or a new body of water to occupy. This makes sense in the driest continent, where water bodies are often ephemeral. They are often attracted to lights at night, occasionally arriving in huge numbers.

Dytiscid larvae take air from the surface through their terminal pair of spiracles. This Queensland specimen is about 14 mm in length.

The yellow-striped diving beetle, *Sandracottus bakewelli* (subfamily Dytiscinae) (10 mm), occurs in the Northern Territory, Queensland, South Australia, and Western Australia.

One of the smallest dysticids is *Hydroglyphus mastersii* (subfamily Hydroporinae) (3 mm). It is distributed in Queensland, the Northern Territory and Western Australia. The closely related *H. balkei* is even smaller (2 mm).

This species of *Cybister* is about 24 mm in length. Representatives of this genus can be found throughout Australia.

Rhysodidae

Wrinkled bark beetles

- body elongate, 4–8 mm long
- shiny, dark reddish-brown to almost black
- antennae are moniliform (bead-like)
- pronotum has deep, longitudinal grooves
- head and elytra are also characteristically adorned with striation and sculpturing
- legs are short and stout

These slow-moving beetles live in decaying, moist wood and it is believed that they feed on slime-mould plasmodia that grow in this environment. The plasmodia accumulate in the deep furrows of the beetle's cuticle and it is presumed that they may carry these organisms as 'starting cultures' from one habitat to the other. Previously it was believed that this yellowish substance was a secretion of the beetle, which was probably associated with ants.

The larvae are elongate, fusiform and live in the same habitat as the adults. There are five genera and 13 species known mainly from Australia but there are a number of undescribed species in collections.

Leoglymmius lignarius (subfamily Rhysodinae) (8 mm) is distributed in the eastern and southern parts of Australia, from coastal eastern Queensland, New South Wales, Victoria and Tasmania.
Drawing: F Nanninga, CSIRO

Carabidae

Ground beetles

- body shape usually elongate and dark, often fused with metallic colours, 2.5–80 mm
- elytra are usually striate, often handsomely sculptured
- hind coxae divide the first abdominal segment (a typical characteristic to all members of the Adephaga)
- antennae are usually 11-segmented, thread-like, or bead-like, rarely form a 2- or 10-segmented, flattened, broad lamina
- antennae stem from between the eyes and mandible
- legs are usually long and strong, adapted for fast running
- tarsal formula: 5-5-5

The ground beetles form one of the largest families of beetles. They are classified in 1500 genera and about 30 000 described species distributed worldwide. At present the Australian fauna consists of 295 genera and about 2575 described species and subspecies.

Carabids are typically terrestrial insects, hence their common name 'ground beetles'. Some species live in leaf litter, but many live under the bark of trees or in decaying timber. Some roam on the trunks or in the foliage of trees, bushes or other plants, while others favour the edges of streams and ponds or wetland habitats.

Because of their enormous diversity, carabids have only a few distinctive characteristics. Some groups have short legs, some dig into the soil, others live under rocks and fallen timber. Some subterranean or cave-dwelling carabids have reduced eyes; others are completely blind.

Many ground beetles can fly well, while others lack the second pair of wings necessary for flight. Some are herbivorous and can cause damage to agriculture. Most, however, are fast-moving predators with excellent vision and strong, sharp, pointed mandibles. They are usually dark in colour,

This ground beetle larva of the genus *Craspedophorus* (subfamily Panagaeinae) is a typical campodeiform carabid larva. The last segments of the abdomen are somewhat obscured in this photograph.

The arboreal *Helluonidius cyanipennis* (subfamily Helluoninae) is about 18 mm in length and inhabits the forests of the Wet Tropics of northern Australia. Its flattened body enables it to hunt for small arthropods under the bark of trees.

This species of *Craspedophorus* (subfamily Panagaeinae) is about 13 mm in length. Nothing is known about their biology. Presumably they are predators, found in many different habitats under logs and rocks in most parts of Australia.

The largest Australian carabid *Hyperion schroetteri* (subfamily Carabinae) may reach almost 80 mm in length and is much sought after by collectors. It is attracted to light at night. Photo: A Urban

The caterpillar killer, *Calosoma shayeri* (subfamily Carabinae) (20 mm), is an ardent slayer of caterpillars, especially army and cutworms. It hides during the day but is very active during the night. Photo: O Kelly

mostly black, sometimes with metallic glitter, but some are brightly marked. The larvae are almost always campodeiform with a 10-segmented abdomen and, like the adults, are predaceous or at least carnivorous. Their antennae are usually 3- to 5-segmented.

Chemical defence is one of the characteristics of adult carabids. When stressed, they release repellant liquids from their pygidial glands through orifices on each side of the anus. In most cases this startles an adversary and the beetle can escape unharmed. Some carabids have an even more effective method of defending themselves: with an audible crack, they forcibly eject a puff of acrid, gaseous substance, which usually repels an attacker.

Predaceous carabids are considered 'beneficial' insects, as they are effective biological controllers of many harmful forestry and agricultural arthropod pests. Carabids that prefer undisturbed habitats are often used as environmental indicators. The number of species and individuals within a specified area gives good indication of the condition of the environment.

Members of the subfamily Carabinae are usually large, attractive beetles, sought after by collectors. In many parts of the world they are protected by wildlife regulations. The largest, *Hyperion schroetteri* can reach almost 80 mm in length and is considered quite rare. *Hyperion* is an endemic genus with *H. schroetteri* the only species. It is distributed in New South Wales, Victoria and South Australia. It is believed that these beetles live in the decaying debris accumulated in tree hollows but a few adult specimens have been found in and under rotten logs where they were hunting the larvae of scarabaeoids and perhaps other arthropods.

The caterpillar killer, *Calosoma shayeri*, is a nomadic species that occurs in most

parts of Australia except the hot and wet north. It occasionally appears in huge numbers, strongly attracted by UV-emitting lights. Such large masses of these beetles usually don't stay long in one place – they move on swiftly and within 24 hours they can vanish completely.

Harpalinae is one of the largest subfamilies of Carabidae and has a worldwide distribution. The genus *Gnathaphanus* is widely spread all over Australia as well as in Japan, the Philippines, Indonesia, New Guinea and a number of Pacific islands. Members of this genus are granivores (grain eaters) and omnivores. Some species have travelled around the world as 'hitchhikers' with shipments of grain and other stored products. About 15 described species live in Australia.

The large genus *Clivina* (subfamily Scaritinae) has a worldwide distribution with about 109 described Australian species, but at least as many again await description. Not much is known about their biology. They probably feed mainly on small invertebrates such as earthworms, other

Members of the genus *Gnathaphanus* (subfamily Harpalinae) are usually grain eaters. They are small (4–10 mm), usually black and difficult to identify.

This small carabid, *Clivina biplagiata* (subfamily Scaritinae) (5 mm), is a denizen of eastern and northern Australia from Victoria to North Queensland and northern Western Australia.

This handsome species, *Drypta australis* (subfamily Harpalinae) (10 mm), is indigenous to southern and eastern Australia. It favours wet, swampy environments where it preys on small arthropods, especially leafhoppers.

The flightless, predaceous carabid, *Carenum transversicolle* (subfamily Scaritinae) (12 mm), lives in the soil, moving about only in the darkness of night. It occurs in the Lake Eyre basin, the Mac Donnell Ranges and the Finke River.

Bombs for self-defence

Perhaps the best-known example of chemical defence among beetles is provided by the bombardier beetle (subfamily Brachininae). Probably millions of years before humans invented capsicum spray for self-defence, this small ground beetle already had it. When disturbed it appears to use its entire abdomen as a pressure pack, repeatedly releasing through its backside puffs of poisonous, acrid gas – up to 80 shots within four minutes![10] Each of these is accompanied with a sound – hence the name 'bombardier' – adding to the repulsive effect. The paussid beetles (subfamily Paussinae) also have the ability to emit clouds of acrid-smelling gas.

The bombardier beetle, *Pheropsophus verticalis* (16 mm), occurs usually on the sandy shores of rivers in most parts of Australia, New Guinea, Timor and other islands in their vicinity, and as far east as the Solomon Islands. It can fly well and is sometimes attracted to artificial lights at night. Photo: O Kelly

For the love of ants

Members of the subfamily Paussinae are considered rare, but this may be because of their secretive life style. Most Australian species belong to the genus *Arthropterus* and can be found in ants' nests. The larvae provide an appeasing secretion to the ants, thus securing their presence and immunity in their host's nest. Not the most gracious of guests, they repay the hospitality by eating the ants' larvae!

Adult *Arthropterus* lack glands that emit a secretion, therefore it is presumed that their association with ants may be of a different nature. *Arthropterus* species are widely spread across Australia. None of the species is common, although some are more frequently seen as they sometimes come to lights at night. The most conspicuous morphological feature of the adult are the antenna with its 11 (usually only 10 visible) flattened segments forming a lamina.

This *Arthropterus* species is about 16 mm in length. As the adult beetle doesn't have any 'offering' to bribe ants with, it has developed strong, smooth armour to protect itself against any possible attacks.

insects and their larvae. Some, however, are known to be polyphagous, feeding on plant matter.

Members of the subfamily Cicindelinae are efficient predators. With a few exceptions (e.g. *Tricondyla*) they have a very distinctive appearance. Their head points downwards, their eyes are large and their exoskeleton often has significant markings and a metallic shimmer. Cicindelines are very alert beetles, mostly diurnal, but those of the *Megacephala* genus are nocturnal hunters. This genus is widely distributed all over the continent.

Members of the subfamily Pseudomorphinae appear to be very different from the rest of the Carabidae. Their flattened, oval-shaped body is an adaptation for living under the bark of trees, especially *Eucalyptus*. Pseudomorphines are believed to be myrmecophilous. Adult beetles have been observed within or in close proximity to ant nests – the ants possibly feed the beetle larvae.

Dystipsidera sericea (subfamily Cicindelinae) (10 mm) is a fast-moving predator with excellent vision. The species of this genus are arboreal, diurnal and live in the eastern part of the continent, mainly in north-east Queensland.

The tree-trunk tiger beetle, *Dystipsidera flavipes* (subfamily Cicindelinae), hunts for small insects on the smooth trunks of *Eucalyptus* trees. If threatened, it can fly away very quickly but usually returns to the same spot after a short while.

Megacephala australis (subfamily Cicindelinae) (14 mm) occurs only in the eastern and south-eastern parts of Australia. A nocturnal predator, it lives near rivers and streams but also at the shores of salt lagoons.

Unlike most tiger beetles, *Tricondyla aptera* (subfamily Cicindelinae) (16 mm) lacks the ability to fly. Its black colour is also uncharacteristic. Its huge, bulging eyes are indicative of excellent vision. *Tricondyla* is an arboreal predator of the closed forests of north-east coastal Queensland.

A tiger of a beetle

Carabids belonging to the subfamily Cicindelinae are finely built with long, slender legs and have an alert attitude. They are ferocious predators, hence their common name: tiger beetles. A cicindeline has a downward pointing head with large eyes, wider than its prothorax and elytra that lack striae, but often decorated with patterns of various colours. Most species show a metallic shimmer.

Some tiger beetles hunt by stealth, patiently waiting until potential prey comes near. Others attack with a sudden rush. The larvae are avid hunters too – they live in vertical burrows, positioning themselves at the entrance, grabbing any small arthropod that ventures within striking distance. Adults of most species can run very fast and can open their wings and fly in a split second. Some are attracted to lights at night, but even on such occasions, when most insects are dazzled by the brightness, they relentlessly carry on with their predatory activities. Cicindelines live in most parts of Australia.

This small tiger beetle, *Cicindela semicincta,* is an alert, fast-moving predator of small insects. Its favoured habitat is near flowing water, where it can be seen on tree trunks, but also on the ground. It occurs almost everywhere in Australia, except the arid interior of the Northern Territory.

This long-necked ground beetle, *Clarencia aliena* (subfamily Odacanthinae) (7 mm), is associated with reeds in swampy wetlands of coastal Northern Territory and eastern Australia from Cairns to New South Wales. It flies well and it is attracted to lights at night. There are four described species known of in this genus.

Like other members of its genus, *Sphallomorpha biplagiata* (subfamily Pseudomorphinae) is predaceous. These beetles can fly and occasionally come to lights at night.

The burrowing, predaceous *Euryscaphus carbonarius* (subfamily Scaritinae) (15 mm) lacks a second pair of wings. It leaves its hiding place only at night to hunt small invertebrate animals, using its strong mandibles to crack even the hard skeleton of other beetles. It lives in the inland arid zone. Seven species of this genus are known. Photo: O Kelly

The large, nocturnal *Mecynognathus daemeli* (subfamily Pterostichitaeinae) can reach the formidable size of 75 mm. With its formidable, asymmetric jaws, it is an effective predator of any small animal, even those that are slightly bigger than the beetle itself. It inhabits the forests of northern Cape York Peninsula in Queensland.

The tiny *Pentagonica vittipennis* (subfamily Pentagonicinae) (3 mm) lives in leaf litter on the forest floor, preying on minuscule invertebrates. It flies well and occasionally is attracted by lights at night. It occurs on the eastern parts of Australia, as well as south-west Western Australia.

The small, vividly-coloured *Microlestodes atrifasciatus* (subfamily Lebiinae) (4 mm) lives on tree trunks and in the leaf litter of closed forests of North Queensland. It probably hunts for small insects and larvae. About 14 small species of *Microlestodes* are distributed over almost the whole of Australia.

Hydrophilidae

Water scavenger beetles

- body inverted boat-shaped (convex above, flat below), colour usually dark, olive-brown, sometimes reddish or black, rarely metallic, 1–40 mm in length
- antennae 7–9-segmented, short, 3-segmented club, cupuliform, maxillary palps usually longer than antennae
- metasternum often keeled with sharp spine at rear
- hind tarsi often flattened and equipped with thick setae
- tarsal formula: 5-5-5, rarely 4-4-4

These are mainly aquatic beetles, however in Australia some are associated with flowers (*Pseudohydrobius*). The cuticle, especially on the dorsal side is sometimes sculptured, but most species have smooth, shiny surfaces. Their antennae are ending in a 3-segmented pubescent club, proceeded by a cup-like process.

Hydrophilids are rather poor swimmers, although some can propel themselves through water at considerable speed. Many of them resemble dytiscids but they can be separated quite easily as the latters' maxillary palps are always shorter than their thread-like antennae (and dytiscids are convex below and relatively flat above). Their method of swimming is different too: hydrophilids alternate their legs while dytiscids move them like oars, symmetrically.

Species of *Hydrobiomorpha* (subfamily Hydrophilinae) (12 mm) occur in northern Australia and New Guinea. Larvae and adults live in flowing fresh water where they scavenge for debris amongst the aquatic vegetation. The silvery layer underneath is its trapped air reserve.

Members of the hydrophilid subfamily Sphaeridiinae are terrestrial. They prefer environments of high humidity, like decaying organic matter, even moist animal dung. Those living in fresh dung are often mistaken for coprophagous scarabs. A close examination with a magnifier reveals of course that their antennae are clubbed and not lamellate, as scarabs have, and the legs are thickly setose, but not toothed like scarabs.

The more typical, aquatic hydrophilids usually inhabit still or very slow-flowing waters with adequate flora and detritus to hide amongst and feed on. Those species which are strong swimmers live in faster flowing streams. Adults take air from the surface and store it in their ventral pubescence and in a cavity between the abdomen and elytra.

Aquatic hydrophilids encapsulate their eggs in a silken cocoon. This has an elongated, snorkel-like extention that assists

the circulation of air within. The cocoon is attached to vegetation, above the water's surface. Most larvae are aquatic and breathe air from the surface through their spiracles.

Most species can fly well, traversing great distances and many are drawn to artificial lights at night. Adults are scavengers, while the larvae are predators, hunting small invertebrates and probably some vertebrate animals too, such as small tadpoles and fish. They are cannibalistic, if the opportunity arises.

The Hydrophilidae is represented in Australia by 44 genera and 208 species.

This *Berosus* sp. (subfamily Hydrophilinae) (2 mm) is a tiny water scavenger with a metallic lustre. The genus is widely distributed throughout Australia. The larvae have gills by which they obtain oxygen from water. The adults of most species are attracted to lights at night, sometimes in very large numbers.

Helochares sp. (subfamily Hydrophilinae) (5 mm). This small water scavanger's preferred habitat is flowing water. *Helochares* species occur all over Australia, except the arid south-east Northern Territory. They fly to lights at night.

This *Hydrochus* sp. (subfamily Hydrochinae) (3 mm) is not easily found as it usually clings to aquatic plants, remaining motionless for long periods of time. The genus is distributed more or less worldwide with 25 species in Australia. They live in ponds or slow-flowing streams. Little is known about their biology.

Spercheus spp. (subfamily Spercheinae) (3 mm) live in stagnant ponds and slow-flowing streams. The two species of this genus have a peculiar habit of walking upside down on the underside of the water's surface film. *Spercheus* is found in Australia, New Caledonia and Indonesia.

Histeridae

Hister beetles

- body compact and ovoid, flattened, sometimes cylindrical, strongly sclerotised, and shiny black, bronze or metallic bluish-green, 1–16 mm in length
- antennae short and elbowed, ending in a 3-segmented club
- elytra truncated, exposing 1–2 tergites
- tarsal formula: 5-5-5 or 5-5-4

Hister beetles are small to medium size, very compact, usually slow-moving insects. The head is deeply inserted into the prothorax but clearly visible from above. Many species have prominent biting mandibles. The short antennae can retract in ventral depressions of the prothorax. The legs are also quite short and broad and, like the antennae, when retracted can fit tightly against the underside of the body. The elytra are short, leaving the propygidium and pygidium exposed.

Histerids occupy a variety of niches; they can be found on cadavers and other decomposing organisms, in bird and small mammal nests and as symbionts, in the company of ants and termites. Adults and larvae, as far it is known, are predators, preying on insect larvae, often fly maggots, and possibly other small, soft-bodied invertebrates.

The Australian fauna consists of 40 genera with 186 species. Nine species of exotic histerids (mainly from South Africa and Java) have been successfully introduced to Australia as biological controllers of various fly and weevil larvae.

This *Saprinus* sp. (subfamily Saprininae) (5 mm) is a bright metallic beetle, often seen on carcasses. However, it is not a carrion eater but a hunter of small insect larvae which live in the decaying flesh. The genus of 10 described species is widely spread in Australia. About half of the species are not indigenous, but introduced from South Africa.

Hydraenidae

Minute moss beetles

- body elongate moderately flattened, 1–3 mm long
- 6 or 7 abdominal sternites
- elytra covering abdomen
- antennae 8- or 9-segmented, ending in 5-segmented antennal clubs
- maxillary palpi long, usually longer than antennae
- tarsal formula: 5-5-5 or 4-4-4

Hydraenids are small aquatic beetles, resembling hydrophilids in appearance, however they differ by having 6 or 7 visible abdominal sternites while Hydrophilidae have 5. Their antennae is 9-segmented (rarely 8-segmented), ending in a 5-segmented club (sometimes 6-segmented). The antennal club of hydraenids is sometimes preceded by a cupule, while the hydrophilid antennal club is 3-segmented and always preceded by a cup.

Hydraenids are aquatic and feed on algae. They live in a variety of habitats, mainly in still and running water, but also on wet rock faces, marine rock pools, seabird nests and inland salt lakes. There are 8 genera and 55 species known from Australia.

The species *Hydraena luridipennis* (subfamily Hydraeninae) (2.2 mm) occurs in the eastern parts of Australia. There are 28 other species of the genus found throughout the continent.
Photo: J Gooderham & E Tsyrlin

Ptiliidae

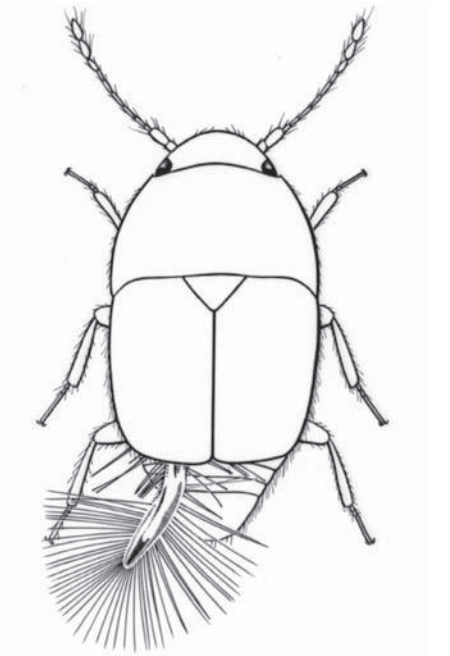
Feather-winged beetles

- body flat, minute, oval to elongate-oval, brown or black, 0.4–1.5 mm long
- antennae long and 10- or 11-segmented, ending in 2 or 3-segmented hairy loose club
- scutellum large and triangular
- apices of elytra rather truncated, exposing abdomen
- flying wings of feathery appearance
- tarsal formula: 2-2-2, rarely 3-3-3

These small beetles are aptly named, as their second pair of wings is feather-like. The wings are actually very narrow and without venation, but they are fringed with long hairs, making them look like feathers. They are often exposed beyond the elytra, which are usually slightly abbreviated.

Ptiliid larvae are elongate, with 3-segmented antennae. They have prominent thoracic legs and unsegmented urogomphi. Adults and larvae inhabit mouldy, rotting plant material and fungi, such as moist leaf litter, moss, compost, dung and decaying seaweed. They mainly eat spores and hyphae of various fungi growing in these humid environments, but some live in symbiosis with ants and most probably feed on the secretions of ant larvae.

Feather-winged beetles are quite common, but being so minute and cryptic, they are seldom noticed. Nineteen genera and 49 described species are known from Australia.



Species of the genus *Acrotrichis* (subfamily Acrotrichinae) (1 mm) live among leaf litter in coastal south-east Australia. They can fly but rarely seek artificial lights at night. All five Australian species were described in 1930–32. It is more than likely that a renewed interest would yield more 'new' taxa.
Drawing: A Hastings, CSIRO

Leiodidae

Small fungus beetles

- body oval, elongate to almost spherical, dorsally flat or convex, ventrally flat or concave, often pubescent, some shiny, colour dark brown to reddish-brown, 1–5 mm long
- antennae 10- or 11-segmented, ending in loose 3- to 5-segmented clubs, in which segment 8 is usually smaller than segments 7 and 9
- hind coxae close together or touching
- tibiae often expanded and spiny
- tarsal formula usually 5-5-5

Leiodids differ from most other families in the Staphylinoidea by their long elytra that cover the entire abdomen, and by the ability of some of the species to roll into a ball. Some groups depart from the usual 5-5-5 tarsal formula. Leiodidae has a worldwide distribution.

Adults and larvae can be found on various fungi and slime moulds, but as a general rule, these are mainly the shiny species, while the pubescent ones can be found on or near cadavers and some subterranean animal nests (including those of ants). They also can be found in forest leaf litter and under bark.

Many Tasmanian *Nargomorphus* species (subfamily Cholevinae) are common in decaying logs and vegetation where they feed on spores and hyphae. Some *Nargomorphus* species feed on puffball fungi

This species of the genus *Nargiotes* (subfamily Cholevinae) (2 mm) is a scavenger, living in leaf litter.

(Lycoperdacea), but most probably they also feed on related organisms in leaf litter and accumulated flotsam on or near the banks of streams.

Species of the genus *Myrmecholeva* (subfamily Camiarinae) are associated with ants. Earlier workers suggested that they predated on ant larvae but now it is supposed that they are obligate ant guests, feeding on the exudates of their hosts' larvae. Adults and larvae have suctorial mouthparts, adapted to sucking.

These little beetles have been re-classified a number of times and in the past they were known as Catopidae or Anisotomidae. Presently there are 23 genera and 105 species of Leiodidae in Australia.

This *Nargomorphus* sp. (subfamily Cholevinae) (2 mm) lives in decaying organic matter and is quite common in accumulations of wooden debris after floods. Some species feed on dung and carrion. This specimen was photographed in north Queensland.

Myrmecholeva acutifrons (subfamily Camiarinae) (2 mm) is associated with ant nests in south-eastern Australia, from New South Wales to Tasmania. Other members of the genus possibly feed on particular moulds that occur in, and outside of, ant nests. Very little is known about their biology.

Scydmaenidae

Minute ant-like beetles

- body in most species somewhat 'ant-like' in appearance (pronotum strongly constricted at base and apex), convex, with pubescence of various densities, brownish or black, 0.7–9 mm in length
- antennae 11-segmented, moniliform and weakly clubbed (or with abruptly separated club in some species, especially in *Euconnus*; or without club in *Clidicus*)
- penultimate segment of maxillary palpi enlarged
- elytra cover entire abdomen, sometimes one tergite exposed
- tarsal formula: 5-5-5

These small beetles resemble ants. Most of them are about 2 mm in length, although *Clidicus abbotensis* from north Queensland is a veritable giant amongst scydmaenids with a body length of 9 mm. In most scydmaenid species the head is constricted posteriorly, forming a 'neck', and the pronotum narrows where it joins the elytra, thus creating a 'waist'. However, the Australian species of *Cephennodes* and some *Euconnus* do not show such constrictions.

Not much is known about the biology of scydmaenids and their larvae, which are short, wide and flattened, with labrum fused to the head capsule. Their second antennal segment is sometimes enlarged to a club-like shape. Adults and larvae live in moist substrates, such as leaf litter, rotten wood, moss, compost, under bark of dead trees, logs and rocks.

Information about feeding on mites has been repeated many times in literature related to all scydmaenids, while it should be limited only to one tribe, Cephenniini, which have a pair of suction discs on the labium to firmly hold oribatid mites when they are being 'processed' with specialised mandibles. All other tribes lack such modifications of the mouthparts and they are probably general predators. Some live in the nests of ants or termites. Thirteen genera with 203 named species are known from Australia.

This unidentified species of *Euconnus* (2 mm) lives in North Queensland rainforest litter. These ant-like beetles are carnivorous, feeding mostly on minute invertebrate animals.

Silphidae

Carrion or burial beetles

- relatively large flat beetles, body 16–40 mm long
- long antennae clubbed (club 3-segmented, finely pubescent)
- fore coxae large and projecting
- either elytra short exposing 4–5 tergites or long, tuberculate and expanded to apex, covering abdomen
- tarsal formula: 5-5-5

As their name implies, the adults of these beetles live on the carcasses of animals. Adult females of some species feed their larvae on carrion or maggots. Although much is known about the habits of Palaearctic and Holarctic carrion beetles, the biology of the Australian species is virtually unknown. They mainly occur in forested regions within 300 km of the coast, where rainfall creates a moist environment. They are attracted to lights at night.

Very little is known about the biology of the conspicuous species *Diamesus osculans*. Based on studies of closely related overseas species, it is presumed that it buries corpses of small animals by digging underneath them, burrows under or near the buried carcass and prepares a chamber where it lays its eggs. The newly hatched juveniles are fed by their parents with predigested food. Only after the second moult can the larvae feed by themselves. This species also frequents large carcasses, far too big to be buried and its method of breeding most probably differ from overseas species.

The species *Ptomaphila lacrymosa* is also associated with carrion. It has been observed feeding on fly larvae, which lived in the decaying flesh of a carcass. Closely related overseas species also eat vegetable matter and some are pests of horticulture. The biology of *Ptomaphila* is not fully researched yet.

Only three species in the two genera, *Diamesus* and *Ptomaphila*, are known from Australia.

This carrion eating *Diamesus osculans* (22 mm) is feeding on a dead bandicoot. It occurs in the northern and eastern coastal regions of Australia, in New Guinea and from South-East Asia to India.

This handsome species, *Ptomaphila lacrymosa* (20 mm) is also associated with carrion. It occurs in heathlands and forests in most parts of Australia except the very dry centre and the north-west.

Staphylinidae

Rove beetles

- body usually narrow and elongated, 0.5–20 mm in length
- elytra typically very short, leaving more than half of the abdomen exposed
- mostly dark in colour, some metallic or brightly coloured

The appearance of rove beetles may be diverse, but they are mostly easy to recognise – with their short elytra and elongated body they look like earwigs (Dermaptera). Earwigs, however, have two cerci while rove beetles have none.

Rove beetles are one of the largest and most successful beetle families, occupying almost all terrestrial habitats. Some are also semi-aquatic, partially living in or near bodies of water, marshes, ponds and streams, even at tidal pools.

Most species live in decomposing plant and/or animal matter – in leaf litter, in the nests of birds, mammals and insects, such as termites, ants, wasps and bees. Most adults are predators, some are parasitoids of other insects, but many feed on fungal spores, hyphae or algae, while others eat detritus of various kinds. Many species defend themselves against attackers by exuding either acrid or foul-smelling liquids and some larger ones are capable to inflict painful bites with their strong mandibles.

This attractive rove beetle belongs to the tribe Xantholinini (subfamily Staphylininae) (9 mm). It is a predator of various insect larvae and other, soft bodied arthropods. Here it is on a rat carcass, teaming with maggots. Xantholinini is distributed worldwide.

Actinus macleayi (subfamily Staphylininae) (12 mm) is a scavenger, feeding on all sorts of organic matter, and probably a predator too. It is widespread, occurring mainly in the eastern parts of Australia.

This species of *Actinus* (subfamily Staphylininae) (13 mm) is a scavenger and an opportunistic predator. It is eating the larva of a tachinid fly that is a parasite of a butterfly chrysalis, in north Queensland.

This species of *Stenus* (subfamily Steninae) (6 mm) has elongated mouthparts, functioning like a chameleon's tongue. Adults and larvae are predatory on small, soft-bodied arthropods such as Collembola.

Despite their small elytra, most species have functional flying wings. These are folded away under the elytra in a complicated manner, however they can be spread quickly and the beetles can become airborne very rapidly. Many staphylinids are attracted to light at night and on some occasions they appear in huge numbers.

Staphylinid larvae are variable in appearance, but typically they are narrow and elongate with a well-developed epicranial stem on the head.

Among the staphylinids there are a few exceptional forms such as *Sartallus signatus*, which is a small, yellowish and oval beetle, found on beaches under carrion.

The genus *Stenus* (subfamily Steninae) is distributed worldwide with 27 species in Australia. They are all diurnal predators with mouthparts telescopically elongated, functioning like a chameleon's tongue. Based on overseas studies, some members of this genus can walk on the surface film of water. They don't just walk but glide. They achieve this by ejecting a chemical from their anal glands which reducing surface tension, acting like a jet propellant. Some species live on banks of bodies of fresh water (lakes, rivers, ditches), while others are not restricted to aquatic habitats, and they can be found on shrubs in wet forests.

A peculiar group of rove beetles, the members of *Paederus* and closely related genera belonging to the subfamily Paederinae, are known as whiplash beetles. These pretty little beetles can cause a rather unpleasant skin condition in humans, known as Paederus dermatitis. The largest outbreak was reported from central Queensland, in 1998. The medical knowledge of this acute blistering disorder is still quite inadequate.[11] A secretion from these beetles can cause an allergic reaction

that is treated with antihistamines or, in severe cases, with adrenalin. The toxin, known as paederin, may also have some therapeutic effects and can be harnessed to heal chronic lesions in humans and cure cancerous growths.

Pselaphinae (formerly Pselaphidae) is now considered a subfamily of Staphylinidae. The *Australian Faunal Directory* records 579 species in 163 genera. In addition, there are about 1600 undescribed species in Australia. They are reddish or yellowish beetles of distinctive shape, 0.75–3.5 mm in length and can be distinguished from most other staphylinids by their non-flexible and stout abdomen of which usually 5 or 6 sternites are visible. Their antennae are clubbed, often with less than 11 segments and the maxillary palpi are usually long. The tarsal formula is 3-3-3 or less. Antennal and tarsal segments sometimes are reduced to the minimal, in some species are fused and these seemingly have only one segment of either or both organs. Very little is known about the larvae of this group. Adults can be found in damp, decaying leaf litter, in humus and moss. Some species prefer gravel and sand near streams, others live in the soil. Adults and larvae are believed to be predaceous, mainly feeding on small invertebrates such as mites and Collembola.

Members of the supertribe Clavigeratae (subfamily Pselaphinae) are all believed to live in symbiosis with ants. They do not only live in the nests of these insects but also move along with their hosts, marching in columns, searching for food and new habitats. The beetles feed on living or dead larvae of the host ants, and it is believed that they may also be fed by trophallaxis, the exchange of nourishment between the beetles and the ants.

This is a species of the genus *Pinophilus* (subfamily Paederinae) (9 mm). Like its relatives of the genus *Paederus*, it can also cause dermatitis in humans. It occurs in open forests in Queensland.

This rove beetle of the genus *Scymbalium* (subfamily Paederinae) (10 mm) has a secretion that may cause an allergic reaction in sensitive humans. It occurs in the Wet Tropics and is relatively common.

This is a species of the genus *Tinaroo* (subfamily Pselaphinae) (6 mm). Members of this subfamily are believed to have a symbiotic relationship with ants.

Lucanidae

Stag beetles

- body elongate, some robust, 6–72 mm long
- head prognathous, with prominent mandibles, more so in males, some branched, antler-like
- antennae with long scape, appear to be elbowed, 3–7 segmented club with thick, comb-like lamellae, which can't be folded close
- scutellum visible
- abdomen with 5 visible sternites
- usually brown or black; a few species with lighter dorsal patterns, some vividly metallic
- tarsal formula: 5-5-5

The name 'stag beetles' reflects the appearance of the males of many species, as they usually show prominent, antler-like mandibles. These 'antlers' are often strongly toothed or lined with pubescence. Opinions differ as to their purpose – more than likely, different stag beetles employ their mandibles for different purposes. Some use them as weapons in self-defence and in battles between rivalling males. Others use them to pin down the female during courtship.

The antennae of stag beetles do not have the usual scarabaeoid lamellate form, but are pectinate or comb-like. The distal segments are not leaf-like, but rather similar to the teeth of a comb.

Cacostomus squamosus (subfamily Lucaninae) (25 mm) is a diurnal species that occurs on flowers in eastern coastal forests, from north of Coffs Harbour to Cape York Peninsula. It is usually collected in light traps. Its larvae, like those of most species of Lucanidae, live in decaying wood.

This pair of stag beetles, *Lissapterus pelorides* (subfamily Lucaninae) (30–35 mm), photographed on Mt Kaputar (New South Wales) demonstrates sexual dimorphism. The *Lissapterus* there live under fallen eucalypt trees at sub-alpine altitudes (1200–1500 m). Photo: George Hangay

Sexual dimorphism is also characteristic of this family. Females usually look less spectacular than males, although in some small species, such as those belonging to the genus *Figulus*, the sexes are practically indistinguishable externally.

The males of sexually dimorphic species are often polymorphic as well, they may show a great variety in size and development. Some small individuals can hardly be distinguished from females, while the largest ones exhibit excessively developed mandibles and in some species, equally enlarged heads. This phenomenon is known as hypertrophy. The various stages of this development are also named: telodont (largest), mesodont (intermediate), priodont (smallest). It is believed that the availability of food during the larval stages influences the size of the specimens.

Although they bore into timber, lucanids pose no serious threat to forestry or the timber industry, as the larvae live only in decaying wood. Some species prefer mouldy, fungus-ridden, fallen logs, while others sometimes live in sick, but still standing trees (e.g. *Casuarina* spp.).

Lucanid larvae may be distinguished from other scarabaeoid larvae by their vertical anal slit borne on the tenth segment. Most adult stag beetles are nocturnal, some are attracted to lights at night and some others probably live their entire lives under logs or within decaying timber. The adults of flightless species probably don't eat at all.

In the subfamily Lucaninae, *Cacostomus* species are nectar feeders and *Lamprima* species have been seen feeding on eucalypt and *Acacia* foliage during daylight hours. All *Lamprima* species sport beautiful metallic colours, mainly green but also often infused with some lovely reddish or bluish iridescent hews. Some forms are metallic

The golden stag beetle, *Lamprima aurata* (subfamily Lampriminae) (38 mm), lives in the eastern coastal region of New South Wales and Queensland. Other species of the genus occur in the eastern and south-eastern parts of Australia, in the south-west of Western Australia and in New Guinea.

This larva of the golden stag beetle *Lamprima aurata* was found in the Blue Mountains, near Sydney. The adult is a beautiful, metallic golden-green beetle.

The brown stag beetle, *Ryssonotus nebulosus* (subfamily Lucaninae) (29 mm), commonly occurs in coastal New South Wales and Queensland. It lives in the decaying dead wood of several tree species, including introduced willows (*Salix* spp.).

King of beetles

Our finest stag beetle is the highly-prized king stag beetle, *Phalacrognathus muelleri*. This large, bronzy-green beetle, with its iridescent coppery shine, is one of the largest (23–75 mm) and arguably the most beautiful Australian beetle. It lives in the rainforests of north Queensland.

The king stag beetle has always been much sought after by collectors but, as it was never easy to come by, it escaped extermination. It was believed that the king stag beetle was only associated with trees belonging to the family Meliaceae, especially the red cedar, *Toona australis*. In fact, its larvae have been found in the rotting, fungus-ridden timber of 27 species of trees in north Queensland rainforests.[12]

The king stag beetle is probably more common than it appears to be, thanks to its secretive life. It probably moves around during the night, although it has been spotted on eucalypt flowers and on oozing tree sap during daylight hours. It is only moderately attracted to artificial light at night.

The king stag beetle, *Phalacrognathus muelleri* (subfamily Lampriminae) (75 mm).

violet and hybrids are not uncommon. It is also believed that some species imbibe the oozing sap of injured trees.

Many species of the genus *Lissapterus* (subfamily Lucaninae) occur in the coastal regions of New South Wales and eastern Queensland. They spend their entire lives under heavy logs, partially sunken into the forest floor. Some of these logs are so huge that it is impossible to roll them; therefore the beetles are safe even from the most ardent beetle collectors. Because most of these species are not able to fly, their dispersal is restricted. It is quite possible that many of the isolated, forest-clad mountain tops of the Great Dividing Range and other rainforested peaks of eastern Australia are the homes of a number of yet undiscovered species.

There are three species in the genus *Hoplogonus* (subfamily Lucaninae) and they all live in Tasmania. The males of the species can be more or less separated by the number of notches on their mandibles They are flightless, larvae and adults spend most of their lives under fallen logs in undisturbed, tall, mixed and wet forests and rainforests, with a well-developed litter layer on well-drained soils. Owing to habitat destruction by agricultural and forestry practices *Hoplogonus* species are considered as threatened.

In Australia, 97 species of stag beetles in 17 genera have been described.

This sombre-coloured species, *Lissapterus obesus* (subfamily Lucaninae) (40mm), is one of the less conspicuous stag beetles. Very little is known about its biology and distribution. Photo: O Kelly

Not much is known about Vanderschoor's stag beetle, *Hoplogonus vanderschoori* (subfamily Lucaninae) (24 mm). It has a very restricted distribution in north-east Tasmania, to the south of Blue Tier along the South George River.

A remarkable discovery

In 1973, the discovery by Mr Allan Walford-Huggins of a spectacular stag beetle in high-altitude rainforest at Mt Lewis, Queensland, caused quite a sensation. This slightly metallic, tan-brown beetle, later named *Sphaenognathus queenslandicus,* was the first species of this otherwise South American genus discovered outside its Neotropical distribution zone. It is now considered a relic of an early Gondwanan stock.

Also in 1973, a similar discovery was made on the Blackdown Tableland some 950 km south-east from Mt Lewis. A young bushwalker, Miss Elizabeth Munchow, came upon a dead female stag beetle, which she gave to the coleopterist Mr Ernest Adams, who subsequently passed it on to the Australian National Insect Collection. The chance discovery of another dead female by a Queensland Museum party in similar tall eucalypt habitat at Consuelo Tableland, 150 km south-west of Blackdown led Dr Geoff Monteith, the Museum's insect curator, to begin an intensive search to get the vital male. It took several years of fieldwork, consistent trapping and logrolling to get results – but success came finally. In 1996 a pair of *Sphaenognathus* was found in the traps. This happy event was followed by locating a colony of larvae which was taken to the Queensland Museum, in Brisbane.

Over the next 46 months six males and two females were raised from this colony. A thorough investigation of these specimens revealed them to be different from *S. queenslandicus*. They constituted a species, new to science, which was named *Sphaenognathus munchowae* in honour of the first collector.

Sphaenognathus munchowae (subfamily Lucaninae) (37 mm) lives at high altitude (900–1000 m) in tall forest, dominated by *Eucalyptus nitens*. Its larvae were found under fallen eucalypt logs, partially in the soil. One specimen was under a *Casuarina* log.

Passalidae

Passalid or bess beetles

- body elongate, somewhat flattened, almost parallel-sided, 20–60 mm in length
- elytra strongly striate, with lengthwise grooves
- head prognathous, with ridges and tubercles, sometimes with a median horn
- antennae curved, not elbowed, club comb-like, can't be folded close
- narrow pedicel between prothorax and elytra
- shiny black, except teneral specimens; scutellum not visible
- tarsal formula: 5-5-5

Passalid beetles are very distinctive in appearance and can be easily recognised. They may resemble female stag beetles, but can be distinguished from them by their scutellum not being visible, bent (not elbowed) antennae, relatively short legs and their ability to stridulate. Passalids cannot close their comb-like antennal clubs in a fan-like fashion, as many other scarabaeoids do, but they can roll up the entire antennae, like a fern frond.

These handsome beetles live in and under decaying logs, staying in these places most of their lives. The larvae are typically scarabaeoid, but with a prominent distinguishing mark: they seemingly have only four legs. This is of course only an illusion, the last pair of legs are also present, but in vestigial form, reduced to mere stumps.

Passalids are sub-social insects, living in small colonies, which look like extended family groups and seem to communicate by stridulation. The adults' sound is produced by creating friction between the elytra and the dorsal surface of the abdomen, and the larvae rub together their trochanter and the file-like structure of the mid-coxa to make a high pitched, squeek-like sound.

It is believed that adults care for the larvae and for freshly emerged teneral specimens by preparing food for them. It is also said that fully developed adults protect the colony against intruders, but noting the docile and practically defenceless nature of these beetles, this needs confirmation. Based on our own personal experiences, it is certain, that larvae may still reach the pupal stage without parental care (at least in captivity) and finally emerge as adults.

Some Australian species are attracted to artificial light at night. As a matter of interest, the only newly discovered species during the last 75 years, *Aulacocyclus hangayi,* was collected on a light. Most Australian passalids are found in the north and the east, but they are not known from Western Australia. There are 35 known species in 9 genera of passalid beetles in Australia.

Mastachilus australasicus (subfamily Passalinae) (35 mm) lives under fallen logs in old and relatively undisturbed forests. It is widely distributed in Victoria, New South Wales and Queensland. Larvae and adults live in colony-like associations, consisting of individuals of various ages and numbers.

Trogidae

Hide beetles

- body compact, heavily sclerotised, dull grey to black, dorsal surface sculptured, 7–20 mm in length
- head deflexed, almost completely concealed from above
- antennae 10-segmented, with 3-segmented club
- pygidium concelaed by the elytra
- adults can stridulate

The true colour of hide beetles is difficult to see as they are usually covered with dust and dirt. Generally they appear grey, but after cleaning, they reveal a lustreless darker hue. The dorsal surface of the exoskeleton is usually beautifully sculptured with tubercles and longitudinal ridges.

Hide beetles are necrophagous and favour desiccated carrion, bones of dead animals with dry ligaments and hide. They are usually the last inhabitants of a carcass, cleaning up the remnants, whatever the previous occupants could not make use of. Some live in the nests of larger carnivorous birds and mammals, where they feed on bits and pieces of meat and bones, pellets regurgitated by their hosts, and probably also on excreta. The larvae (which are also necrophagous) are of the usual scarabaeoid 'curl grub' appearance, with three pairs of well-developed legs and prominent claws.

Hide beetles are well distributed all over Australia, but generally prefer the arid interior of the continent. Most of them can fly and some are attracted to lights at night. The best way to find them is to look under the desiccated bones and hides of larger carcasses – several species may be found together.

The *Zoological Catalogue of Australia*[13] lists 52 named species in one genus (*Omorgus*) from Australia. *Trox scaber*, an introduced European species, can also be found here.

Hide beetles of the genus *Omorgus* (10 mm) all look very similar at first glance. The many species can only be differentiated by using detailed descriptions and comparing them with some already determined specimens. This specimen was photographed in North Queensland.

Bolboceratidae

Bolboceratid beetles

- reddish-brown, rarely black, body strongly convex or hemispheric, 7–27 mm in length
- head prognathus
- long, complex shaped horns, protrusions on head and pronotum in males
- antennae 11-segmented with circular, 3-segmented circular, biconvex club
- scutellum large
- elytra cover the abdomen
- legs strongly developed
- adults can stridulate loudly

These handsome insects look like dung beetles, to which they are related. However, they have 11-segmented antennae while dung beetles (Scarabaeidae: Scarabaeinae) have 8 or 9 segments in their antennae. Australian bolboceratids are predominantly reddish-brown, while scarabaeines are mostly black. An interesting characteristic of these beetles is that they have strong, asymmetric mandibles. Most species show significant sexual dimorphism, making identification of the different sexes rather difficult. It is believed (despite statements in earlier publications) that they are not coprophagous, but feed on decaying plant matter, humus and fungi. They excavate deep, usually vertical burrows in the soil, pack them with fodder and lay their eggs there.

This bolboceratid belongs to the genus *Australobolbus* (9 mm). It was photographed in dry sclerophyll forest in North Queensland.

This is the bolboceratid *Elaphastomus gellarus* (12 mm). Not much known about its biology. Photo: O Kelly

Bolboceratids populate mainly the coastal areas of Australia, although quite a few species live inland. They prefer sandy soil, often along dried-out watercourses where their presence is betrayed by heaps of soil brought to the surface where they burrow. Some species are believed to be termitophilous.

Adult bolboceratids are mostly nocturnal and attracted to light at night, often announcing their arrival with loud stridulation. The sound is produced by rubbing a file-like process over the hind coxae. The larvae can also stridulate by rubbing their hind and mid legs together.

The large genus *Australobolbus,* with 45 described species, is distributed across nearly every part of the continent and to New Guinea as well. Like most other bolboceratids, they lead a subterranean life, packing pieces of plant matter into their burrows into which the female lays her eggs. The larvae, after hatching, feed on the accumulated, decaying plant matter. Metamorphosis takes place within the burrow and the adult beetles disperse to find a mate.

All the six described species of *Elaphastomus* live on the eastern part of Australia, from Victoria to northern Queensland. One species, *Elephastsomus meraldus*, collects large quantities of dung in its breeding burrows. This is an unusual habit of the Australian bolboceratids, which predominantly feed on decaying plant matter, humus and fungi.

The biology of Bolboceratidae has been studied only sporadically – not much is known about the details of their lifecycles and habits. Ten genera and 164 described species are known from Australia.

Hybosoridae

Scavenger scarab beetles

- body oval, convex, shiny, dark brown or black, 2.8–12 mm in length
- mandibles sharply curved, visible from above
- antennae very short, 9- or 10-segmented, clubbed

The antennae of hybosorides are endowed with a compact club, resembling that of the Bolboceratidae. They are scavangers, mostly feeding on decaying animal matter, including excreta, and may be trapped in pitfall traps baited with dung or decaying meat.

The larvae can emit a sound using their fore and mid legs as stridulatory organs.

Hybosoridae is a cosmopolitan family, represented in most parts of Australia, including Lord Howe Island, but absent in the arid south-west of the Northern Territory, on Tasmania and other islands.

The species *Cyphopisthes descarpentriesi* (subfamily Ceratocanthinae) occurs in coastal, north-eastern Queensland. It can roll its strongly convex body into a ball (see illustration page 35). Specimens of this species were found in the nests of the termite *Mastotermes darwiniensis*. Presumably it is a symbiont of this termite.

There are 45 species in five genera known from Australia.

This is a species of *Liparochus* (5 mm) found in north Queensland open forest. *Liparochus*, the largest genus of the Australian hybosorids, is also represented in New Guinea and New Caledonia.

Scarabaeidae

Scarab beetles

- body shape variable, usually stout, oval or elongate, 2–60 mm (mostly 2–20 mm) in length
- antennae distinctive, 8- to 11-segmented
- last antennal segments lamellate
- tarsal formula: 5-5-5

Scarab beetles are so diverse and their appearance so variable that it is almost pointless to give a general description of this family. Their most obvious characteristic is their lamellate antennae. Usually the last three or four segments (sometimes more) form a lamellate club, sometimes fan-shaped, that can be spread and/or closed tightly. In related scarabaeoid families, such as Lucanidae and Passalidae, these clubs can not be closed. The clypeus in most cases conceals the labrum or the mandibles, or both. The seventh tergite forms a pygidium and it is often clearly visible.

Sexual dimorphism and polymorphism is frequent among scarabs. The males often have horns, tubercles, and excavations on their heads and prothoraxes while the females are usually much less conspicuous in appearance. The scarabaeid larvae are typically C-shaped, with well-developed, strongly sclerotised heads, 4-segmented antennae and legs which do not stridulate.

The habits of scarabs are just as varied as their appearance. Many are coprophagous, others feed on carrion, on decaying wood, on many parts of live plants, some are ant- and termite-loving. The adults of quite a few species don't eat at all.

Scarabs can be found in a huge number of habitats from the hot tropics to freezing alpine regions. Their diverse lives provide great study opportunities for both professional and amateur coleopterists. The classification of Scarabaeidae has been revised many times in the past and more than likely it will be revised further in the future.

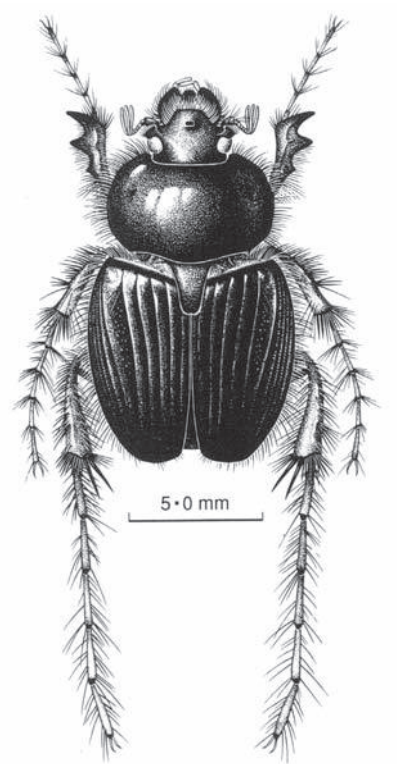
Well over 2200 species in approximately 270 genera are known from Australia. This number is far from constant as new taxa are added to the list continuously. The family is currently divided into 20 subfamilies, but this is also controversial. This book only mentions the most important or conspicuous subfamilies.

Anoplognathus greyanus (subfamily Rutelinae) (20 mm) is a typical scarab beetle.

Scarabaeidae: Aclopinae

Aclopine scarab beetles

This subfamily of Scarabaeidae is probably the least known. *Phaenognatha* is the only genus occuring in Australia. There are eight species occurring in North Queensland and Northern Territory. The adult beetles are about 10–21 mm in length, distinctively brown or black. The males' hind tarsi are conspicuously long. Elytra are separately rounded, labrum and mandibles exposed and the abdomen is very hirsute. Almost nothing is known about the biology of this subfamily. While adults are attracted to lights at night, the females of most species are unknown. Presumably they spend their lives underground. The larvae are also unknown.



A scarab of the genus *Phaenognatha* (subfamily Aclopinae) (15 mm). Drawing: F Nanninga, CSIRO

Scarabaeidae: Aphodiinae

Aphodiine dung beetles

These are some of the smallest scarabs (2–10 mm). Most of the Australian species are black and brown, although one introduced species, *Aphodius fimetarius,* is black and red. Other species are black and yellowish-brown, some with darker markings on the elytra.

They are somewhat elongated, with their hind legs inserted closer to the tip of the abdomen than to the middle legs. The pygidium is covered by the elytra, scutellum is usually well developed. Larvae can be distinguished from other scarabaeid larvae by having 4- or 5-segmented antennae. They lack a hump – which is typical of many other scarabaeid larvae – and fully developed legs.

The biology of most Australian Aphodiinae species is relatively well known. Most are coprophagous. Some are specialised to the dung of certain species of vertebrate animals, while others are general dung feeders. Quite a few species feed on carrion, the detritus in bird and mammal nests, decaying fungi, wood and a variety of decaying organic matter. Pitfall traps with meat or dung bait often capture various species of aphodiines.

The species *Acrossidius tasmaniae* and *Acrossidius pseudotasmaniae* are notorious pests of cultivated grasses, including lawns and pastures. Several exotic species were introduced as biological controllers or pasture improvers. Many species are attracted to light at night.

Aphodiine dung beetles are widely distributed all over Australia with 182 species in 29 genera. However, these numbers are expected to grow as new species are discovered.

The pitchy scarab or pasture chafer, *Ataenius picinus* (subfamily Aphodiinae) (4 mm), is an accidentally introduced species, and is now widely distributed in Australia. It favours open forests, grassland and pastures, frequenting fresh dung.

Scarabaeidae: Scarabaeinae

Dung beetles

These are the 'real' scarabs – the dung beetles. They are robust, roundish and convex-bodied insects, ranging in size from 1.5 to 28 mm, and are usually black or dark brown, sometimes with a slight metallic shine. Some introduced species are more colourful than our endemic dung beetles by having strongly metallic exoskeletons. Their elytra may be lighter coloured, sometimes with darker markings (e.g. some *Onthophagus, Euoniticellus* and *Onitis* species).

The hind legs of dung beetles are situated far back on the body, nearer to the posterior end of the abdomen than the middle legs or about midway between. They share this characteristic feature with another predominantly coprophagous subfamily, the Aphodiinae. However, they differ from them by the visible pygidium and the above mentioned stout and round body shape. Tarsal claws are equal and the elytra are without a membraneous margin. The scutellum is absent, it can be seen only in one genus: *Thyregis*. The front tibia is fossorial as almost all dung beetles are diggers, not only in dung but also in soil. The hind tibia is equipped with an apical spur.

The males and the females of most species differ quite considerably. Males are often larger and have cephalic and pronotal protrusions, while females lack such armatures. The larvae are hump-backed; they have four segmented antennae and their anal opening is usually surrounded by fleshy lobes. Adult and larval dung beetles – as their name indicates – are mainly

The prominent horn on *Coptodactyla monstrosa* (15 mm) makes it easy to identify as a male. It lives in open forests and pastures in coastal north Queensland from Townsville to the Iron Ranges. Adults are about from November to June, but are most active in January.

The largest Australian dung beetle is *Aulacopris maximus* (28 mm). It is uncommon even in its relatively restricted range from Barrington Tops in northern New South Wales to Emundi near the Blackall Range, south Queensland. Living in tall, montane forests, adults and larvae favour the dung of marsupials and human excrement. Photo: G Hangay

The dung beetle's meal

Dung and other decaying organic matter, such as carrion, rotting plants, mushrooms and fruit are bacteria-rich nourishment for the dung beetle. But this doesn't mean that any dung beetle will happily consume any of these substances – they are actually quite fussy eaters.

The indigeneous species usually prefer the dung of native animals and reject that of others. Generally, fresh marsupial dung is the most desirable for these beetles. Some species are so keen to get it absolutely fresh, that they developed prehensile claws (unique amongst dung beetles) and cling to the fur near the cloaca of macropods, waiting for their next meal. As a pellet is extruded by the host animal, the beetle seizes it immediately.

The excrement of introduced animals, such as cattle, horses and sheep are not favoured by most native scarabaeines and once resulted in pastures littered with huge amounts of polluting dung. In the 1960s, CSIRO's Dr George Bornemissza proposed introducing dung beetles from foreign countries where these large herbivores lived. Over a period of 14 years CSIRO imported and liberated more than 45 species from Europe, Asia and Africa. More than half of these are established now; species from the genera *Onitis, Euoniticellus and Onthophagus* being the most successful. Because they bury the dung in the ground, they reduce the breeding grounds of flies, destroy favourable living conditions for gastrointestinal parasites during their free-living stages, and also improve pastures by replacing nutrients in the soil and increasing water penetration and retention.

The story of exotic dung beetle introduction is one of the greatest success stories of applied entomology in Australia.

The northern sandy dung beetle, *Euoniticellus intermedius* (9 mm), naturally occurs in the moist and warm parts of Africa and Arabia. Introduced to Australia in the 1970s, it has become successfully established in warmer regions. A female lays 80–130 eggs during her life. Adult life span is about two months, thus this beetle can have six generations in a year.[16]

The bronze dung beetle, *Onitis alexis* (20 mm), from Africa and southern Europe was introduced in the 1970s and is now well established in New South Wales, Queensland, the Northern Territory and Western Australia. A female can lay up to 250–270 eggs during her lifetime. The adult life span is about three months in summer. The beetles fly at dusk and dawn, seeking fresh piles of cow or horse dung.[15]

Onthophagus ferox (16 mm) is an abundant species in the south-west of Western Australia. It prefers sandy soil in low rainfall areas. Adults are most active from July to November and February to May, and are attracted to lights at night. An isolated population can also be found near Alice Springs.

The genus *Lepanus* contains the smallest dung beetles in Australia. This 2-mm specimen was found in north Queensland feeding on a bird dropping. *Lepanus* is distributed along the east coast of the continent from eastern Victoria to Cape York.

This native dung beetle, a species of *Coptodactyla* (10 mm), is not as fussy as many of its relatives. It will eat the dung of some introduced animals such as the horse. As it is a female, it is quite difficult to determine the species.

coprophagous, although a few species feed on carrion, fungi, fallen fruit and decaying plant material.

A characteristic peculiarity of the genus *Coptodactyla* is that they lack the front tarsi. This may be the result of an evolutionary process, necessitated by their habit of digging in hard soil, where the usually delicate tarsi would be a hindrance. Many individuals are highly worn, their front tibia sometimes reduced to mere stumps and the otherwise shiny surfaces of their exoskeletons are dulled by abrasion. This indicates that the beetles often dig in hard or abrasive soils and such exceptional fossorial activity selected for the loss of their front tarsi.[14]

The 11 described species of *Coptodactyla* live in tropical northern Australia and some of them also occur in New Guinea.

Scarabaeidae: Dynastinae Rhinoceros or elephant beetles

These stout-bodied beetles are mainly black or dark brown. The heaviest Australian beetle is *Haploscapanes barbarossa* (the first described Australian insect),[17] but not all dynastines are of such huge sizes – the smallest species are barely 9 mm long.

Dynastines are quite easy to recognise, although some can be confused with members of the other scarabaeid subfamilies of Melolonthinae and Rutelinae. They can be distinguished by their membraneous labrum, not visible externally (the Melolonthinae has sclerotised labrum, visible externally) and their equal, fixed claws (the Rutelinae has unequal, movable claws).

The biology of this subfamily is far from well known, however the habits and lifecycles of a number of some species have been thoroughly investigated.

Larvae live in the soil, and decaying vegetable matter, including fungus-ridden timber. Some species (*Cryptodus* spp.) live in associations with ants or termites. A number of species feed on the roots of living plants.

This beautiful female *Novapus crassus* (20 mm) is found in Western Australia and the north-western tip of the Northern Territory. Very little is known about its biology, but most probably its immature stages, as those of the majority of the dynastines, are subterranean or at least live in decaying wood and/or humus. Adults are good fliers and readily come to lights at night.

This large (45 mm) rhinoceros beetle larva has strong, sharp mandibles that are formidable weapons, not only for chewing wood but also for self-defence or even for attacking and cutting up another larva. It was photographed on Mt Kaputar in New South Wales.

The larvae have strong mandibles, suited to chewing through timber. They can deliver a painful pinch if annoyed – biting wildly and at random, sometimes injuring their own abdomen. Although they are not normally carnivorous, some species may turn cannibalistic in captivity. While the larvae are usually voracious feeders and increase in size rapidly, in some species the adults don't eat at all.

The adults of most species are nocturnal and many are attracted to artificial lights. Sexual dimorphism is common in Dynastinae. The males of many species have large horns on their heads and equally large pronotal protrusions, excavations and tubercles. Females are usually smaller and less ornate than males. Polymorphism is also evident in many species; size and appearance differences in males are not uncommon.

The introduced Argentinian species *Cyclocephala signaticollis* (16 mm) has become a major pest in New South Wales coastal areas, occasionally infesting lawns and recreational turf in large numbers. The larvae kill the grass by feeding on the roots. The adults superficially resemble small Christmas beetles (Rutelinae: *Anoplognathus* spp.). *Cyclocephala signaticollis* is an unusual dynastine as it is yellowish-brown with some darker markings on its prothorax and elytra.

Some Australian dynastines are known agricultural/horticultural pests. The accidentally introduced, originally African black lawn beetle, *Heteronychus arator,* is a serious pest of cultivated grasses; 194 species in 33 genera are known from Australia.

Rhinoceros or elephant?

One of the largest and most spectacular Australian beetles is the rhinoceros beetle, also known as the elephant beetle, *Xylotrupes ulysses australicus*. This heavily built, chestnut-coloured scarab is found all year around in the northern parts of Australia, but towards the south it is more seasonal and can be encountered mainly in the warmest period of the year, usually around Christmas. The larger males have a double-pointed, curved horn on their heads and a heavier one on their prothoraxes. The horns of small males are much smaller, sometimes reduced to mere knobs and/or single-pointed horns. The females are even more modest in their appearance; they are generally smaller without protrusions on their heads or prothoraxes.

Mating takes place from late December to the end of January or even into February. The males frequently congregate in large numbers on tree trunks and branches, especially those of the poinciana trees (*Delonix regia*). They jostle vigorously, squeaking and hissing, trying to dislodge each other from the tree in a kind of a pre-mating ritual. The sound they produce is created by rubbing part of their abdomen against the ends of the elytra. The hissing squeaks serve as a deterrant against a foe, but sadly it is not much more than a bluff, because the beetle is quite incapable of defending himself against a determined attacker.

Despite its fearful-looking horns, this beetle represents no danger. Only its sharp claws and strong legs can cause some concern for a human with delicate skin. *Xylotrupes* is recognised as a minor forestry and horticultural pest. The adults feed on bark of various ornamental and forest trees and are known to damage pineapples, banana stems and coconut palms.

The elephant beetle, *Xylotrupes ulysses australicus* (60 mm), is a conspicuous inhabitant of the coastal Wet Tropics and subtropics. It is rare or absent in the arid zones and to the south of Coffs Harbour.

Scarabaeidae: Melolonthinae

Chafers

Most Australian chafers are stoutly built, somewhat elongated, reddish-brown to brown or black, sometimes with darker markings (e.g. *Phyllotocus* spp.) rarely metallic green (e.g. *Diphucephala* spp.) or green (*Xylonichus* spp.). They are 3–32 mm in length.

Their tarsal claws are equal and fixed (unlike the unequal and movable claws of the Rutelinae), their mandibles are completely concealed from above, and their externally visible sclerotised labrum, head and pronotum lack horns and other protrusions.

Chafer larvae differ from other C-shaped scarabaeid larvae by an apical antennal segment about as wide as the penultimate segment and a Y-shaped anal cleft. The adults of most species are crepuscular or nocturnal, however, some are distinctively diurnal (e.g. *Diphucephala* spp., *Phyllotocus* spp.).

Many nocturnal species are attracted to light at night, sometimes in huge numbers. Melolonthines are phytophagous and as some species occur in large numbers in their adult forms, they can be serious pests as defoliators of various trees and shrubs. A number of species don't feed as adults. Their larvae, however, cause damage to roots of plants.

The genus *Sericesthis* is widely distributed in the Murray–Darling basin, coastal New South Wales, north-east Queensland, South Australia, Victoria and Tasmania. It has many species, some still to be described and named. The more common ones sometimes occur in large numbers and impact quite significally on the vegetation in their habitats. The larvae of some species

Sericesthis geminata (12 mm) is one of the commonest chafers in New South Wales and coastal Queensland. It is a pest of pastures, lawns and vegetables. The adult is crepuscular; the larva lives in the soil, feeding on humus and the root system of various plants.

Species of *Phyllotocus* are known as flower or nectar scarabs and are important pollinators of plants. They feed on pollen and nectar, especially on *Leptospermum, Eucalyptus* and *Angophora*. This 5-mm specimen was photographed on the outskirts of Sydney.

The chafer's life

Chafers lay their eggs in the soil, usually only once a year. The hatching larva tunnels downwards and begins feeding on the roots of plants. Some species prefer decaying plant matter, such as rotting leaf litter and humus. As it grows, the larva moults several times until reaches its full size.

Once it has arrived at that stage, it makes a small, cave-like cavity, where it pupates. How long the metamorphosis takes place depends on the species and ultimately on weather conditions. If the ground dries out and hardens, the beetle must remain in the pupal cell until rain falls again. Only when the soil softens can it dig its way up to the surface.

Because chafer larvae can be quite abundant, fairly large and feed on the roots of many agricultural and horticultural plants, they can cause serious damage. Our greatest researcher of the Melolonthinae, the late Dr EB Britton, wrote that 'the weight of sheep per acre on Australian pasture may commonly be exceeded by the weight of chafer larvae feeding below the surface'.[18]

The greybacked cane beetle, *Dermolepida albohirtum*, (16 mm) is one of the most harmful pest of sugar cane in northern Queensland. In 1935, in an attempt to control it, the cane toad, *Bufo marinus,* was introduced from South America. Scientists hoped that the toad will eradicate the beetle, but instead it has caused irreparable damage to our native fauna.

The larva of the greybacked cane beetle, *Dermolepida albohirtum* (20 mm), is a typical melolonthine 'curl grub'. It feeds on the root system of sugar cane.

The adult greybacked cane beetle, *Dermolepida albohirtum* (16 mm).

Phyllotocus species are most active during hot, sunny days. At night, or in rainy or cool weather, they hide inside or under flowers. A number of species are gregarious and can be seen feeding and mating on flowers. These specimens (5 mm) were photographed in Tasmania.

feed on the roots of grasses and clover, while the adults on occasions devastate whole sections of forests in eastern Australia.

The 69 described species of *Diphucephala* are distributed over the entire continent, including Tasmania. In the Northern Territory *Diphucephala* occurs only in the north-western parts. Like most melolonthines, these beetles are also plant eaters. Their larvae live in the soil and feed on the root systems of various plants while the adults eat the foliage of a wide variety of herbaceous plants, shrubs and trees.

The 28 species of *Phyllotocus* are distributed in the eastern and the western parts of the continent, as well as in Tasmania, while they are absent in the Northern Territory and most of South Australia (except in the Murray–Darling basin).

Chafers form a large portion of the Australian scarabaeid fauna. At present there are some 117 genera and about 1400 species of melolonthines known from Australia. This number will most certainly grow in the future as most major collections house large numbers of undetermined and many undescribed specimens.

This species of *Diphucephala* (6 mm) is quite common on the outskirts of Sydney.

Scarabaeidae: Rutelinae

Shining leaf chafers

Rutelines are stoutly built, usually somewhat metallic, brightly coloured beetles. Their size varies from 7–35 mm. They may resemble melolonthines or even dynastines, but they can be distinguished from them by unequal and moveable tarsal claws, elytra which don't cover the pygidium, and a head and pronotum without any horns or tubercles.

Many of the Australian rutelines are gregarious, diurnal and quite conspicuous. The adults of most species feed on the foliage of trees and shrubs – *Eucalyptus* and *Acacia* are especially favoured. Mating takes place at any time and the beetles can frequently be noticed as they fly around their foodplants. Many are attracted to light at night, sometimes in large numbers.

The larvae are typically scarabaeoid and in habits are rather similar to those of the Melolonthinae. After mating the female deposits her eggs into the soil and the hatching larvae feed on the root systems of grasses and other plants. Unfortunately they cause damage to some horticultural plants as well as pastures. Adults defoliate eucalypts and acacias. Adults of some species occasionally appear in plague-proportions and become serious forestry pests. They can defoliate eucalypts or acacias completely, causing the premature decline of trees, known as dieback. Grazing lands with fewer trees are in increased danger of attack. The beetles can breed in huge numbers as their larvae find plenty of food under the pastures, but when the adults emerge, they have to feed on the few remaining trees. Defoliation and dieback are the consequence.

Most Australian rutelines live in the higher-rainfall areas, although some species have adapted to the arid zone. Species of the genus *Paraschizognathus* are nocturnal and while the biology of their larvae is more or less the same as the other rutelines, the adults don't feed at all.

The repsimus beetle or black nail beetle, *Repsimus manicatus* (20 mm), with its extraordinary hind legs and colouring, has elytra that resemble black, polished fingernails. The larvae live in sandy soil, feeding on roots and other plant matter. Adults feed on *Callistemon citrinus* and come to lights at night. The beetle is common in New South Wales and eastern, coastal Queensland. Photo: O Kelly

The handsome green chafer beetle, *Anoplostethus laetus* (20 mm), is quite variable, with some forms having more vivid colours than others. They often can be seen in association with Atkinson's Christmas beetle, *Calloodes atkinsoni*, as both species are folivores of *Eucalyptus gummifera*. The species occurs in northern, coastal Queensland and western regions of Western Australia.

Christmas beetles

The most conspicuous and attractive Australian rutelines are the Christmas beetles, which belong to the endemic genus *Anoplognathus*. They occur in most parts of Australia, except some of the arid areas. As their name implies, they usually appear around Christmas time in larger numbers, although quite a few species are present already from November through February. The wet, northern tropics have a few species which are prevalent all year around.

The brown Christmas beetle, *Anoplognathus chloropyrus* (20 mm), is abundant in the Murray–Darling basin, the Great Dividing Range and in coastal Queensland, New South Wales and Victoria.

Anoplognathus rugosus (20 mm) occurs in central Victoria and central New South Wales. This specimen was photographed in Canberra.

The gold Christmas beetle, *Anoplognathus aureus* (12 mm), is much sought after by collectors, but not too often encountered. It lives in north-east Queensland and north, coastal Western Australia.

The dark red Christmas beetle, *Anoplognathus rubiginosus* (15 mm), is a rare species that lives in northern New South Wales, in the Great Dividing Range from Uralla to Tenterfield.

The leaf green Christmas beetle, *Anoplognathus punctulatus* (20 mm), lives in northern, coastal Queensland.

Atkinson's Christmas beetle, *Calloodes atkinsoni* (25 mm), one of our finest Christmas beetles, is found in the northern parts of Australia.

Scarabaeidae: Cetoniinae

Flower chafers

The flower chafers form a very large subfamily of the Scarabaeidae. They can be distinguished from the other scarabaeid subfamilies by having equal tarsal claws, elytra without a membranous margin, an exposed pygidium and they are somewhat flattened. Most are easily recognisable with their striking patterns and metallic or beautiful, glossy colouring.

Adults are diurnal and are important pollinators of many flowering plants, feeding on nectar and pollen. They are fast-flying, alert beetles, ready to take off immediately if threatened. In flight, the elytra are not opened but slightly raised only, to allow the second pair of wings to spread and operate.

Cetoniines in other countries are often attracted to plant exudates and easily lured into traps containing fermented liquids (e.g. wine, beer, honey, fruit). Australian species, however, don't seem to go by this 'rule' as most of them prefer to frequent flowers, especially those of *Eucalyptus*, *Angophora* and *Leptospermum*. The larvae live in humus and eat decaying plant matter, favouring damp, nutrient-rich microhabitats such as compost heaps, damp leaf litter and under fallen logs. Some are associated with ants and can be found in the soil, on the perimeters of ant nests. The Australian fauna consists of 29 genera and 146 species.

Various species of flower chafers often form gregarious, mixed groups on particularly tasty flowers – here an *Angophora* species near Galston Gorge, north of Sydney. Although they consume nectar and pollen and cause some damage to the flowers, they also act as important pollinators.

The colour of the brown flower chafer, *Aphanestes gymnopleura* (14 mm), ranges from entirely black to reddish-brown, with a black scutellum. It is common in coastal New South Wales and also occurs in southern Queensland. Adults frequent *Angophora* and *Leptospermum* from October to February.

The green-velvet flower chafer, *Glycyphana brunnipes* (10 mm), is a relatively common beetle in October to February, on flowering *Angophora, Euroschinus, Kunzea, Leptospermum* and *Tristaniopsis* in coastal New South Wales from Illawarra to south Queensland.

The impressive Macleay's hairy-backed chafer, *Trichaulax macleayi* (25 mm), from the Wet Tropics of north Queensland and New Guinea, favours taller trees and feeds on nectar and pollen of their flowers, usually high above the ground.

The spotted flower chafer, *Polystigma punctata* (14 mm), is common in the Great Dividing Range and the coastal plains of eastern Australia from Victoria to north Queensland. It has been recorded on a variety of flowering plants.

Not much is known about the biology of the black flower chafer, *Aphanestes decorticara* (15 mm), a north Queensland and Thursday Island species. It feeds on nectar and pollen; its larvae live in rotten wood.

The fiddler or fiddler beetle, *Eupoecila australasiae* (15 mm), is also known as the horseshoe beetle. Its imagos can be seen in November to March in southern and eastern coastal areas.

Scirtidae

Marsh beetles

- body ovoid, convex, 3–12 mm in length
- head prognathous
- antennae long, 11-segmented, filiform
- pronotum and prosternum short
- tarsi 5-segmented, segment 4 ventrally lobed

Marsh beetles are not very easy to distinguish from a number of other, similar looking beetles. They vary in colour, however, the most commonly encountered species are shiny brown with relatively flimsy exoskeletons.

They live in wet environments, near swamps, billabongs and other similar kinds of habitats. Adults can be found on vegetation near water. The larvae live in a variety of habitats, usually in or near swamps, slow-flowing or tepid water, even in water-filled tree holes, but some species live in very wet decaying logs on the forest floor.

The larvae of many species are aquatic and near-campodeiform. Early instars of these breath through anal gills. Intermediate and last instars develop abdominal spiracles. They are unique among beetle larvae by having long, multisegmented antennae. They feed on aquatic microorganisms and detritus that they

The marsh beetle, *Macrohelodes crassus* (6 mm), is extremely variable in colour and size (5.5–11.3 mm). It feeds on the pollen and nectar of flowering bushes during daylight hours and is distributed in coastal, forested areas from south Queensland to Victoria and Tasmania. Members of this genus can be recognised by the absence of setae over most of their dorsal surface.

This beetle may be a differently coloured form of *Macrohelodes crassus* (6 mm). Species of this genus prefer coastal, wetter habitats but also live in hilly country or even in higher, alpine environments. The four described species in this genus are distributed over the south-east coastal regions of Australia, from the South Australian/Victorian border to the New South Wales/Queensland border and in Tasmania.

Many *Pseudomicrocara* (5 mm) species have delicate mandibles without teeth indicating that they are pollen eaters, while others have an elongate muzzle, usually associated with nectar feeding species. Some are commonly found on flowers, others only rarely or hardly ever. The larvae live among decaying plant matter accumulated at the edge of still or slow-moving water.

This is a specimen of *Scirtes kaytae* (4 mm) or a similar species from north Queensland. The thickened femora of these beetles are indicative of their ability to jump. The larvae live in decaying leaf litter at the edge of swamps.

The larvae of *Scirtes ruforotundus* (4 mm) are found in water-filled tree hollows with large, wide openings. This specimen was photographed in north Queensland.

filter out of the water with their brush-like mouthparts. Adults fly well and a number of species readily come to the light at night, sometimes in larger numbers.

The Scirtidae (formerly known as Helodidae) is not a well known family of beetles and more species are being studied and described. At present 10 genera and 110 named species are known from Australia.

This underside of this species of *Scirtes* (4 mm) clearly shows its greatly enlarged femora.

Clambidae

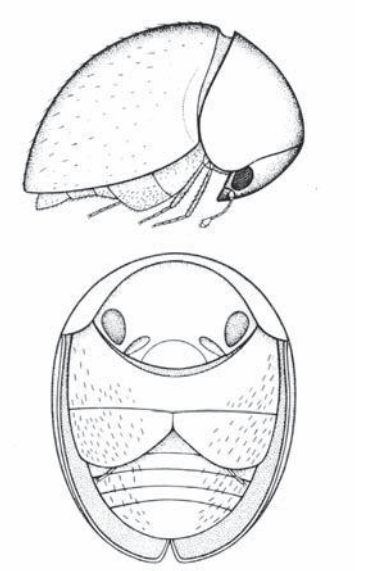
Minute spherical beetles

- body globular, shiny dark brown/black, under 2 mm in length
- head broad, hypognathus
- antennae 8- or 10-segmented, with a 2-segmented club
- tarsal formula: 4-4-4

The main characteristic of minute beetles is that they can roll themselves into a small ball by reflexing their head tight against the sternum. This is a protective gesture, shielding the more vulnerable ventral surfaces of the beetle against an adversary.

The head and pronotum are large and together with their smooth, shiny elytra, they can transform into a pill-like shape, allowing the beetle to simply roll away from danger. Very little is known about the biology of this family, apart of the fact that larvae and adults live in moist leaf litter and some may be myrmecophiles. The adults of some species may frequent flowers.

The Australian fauna consists of 21 species in three genera.



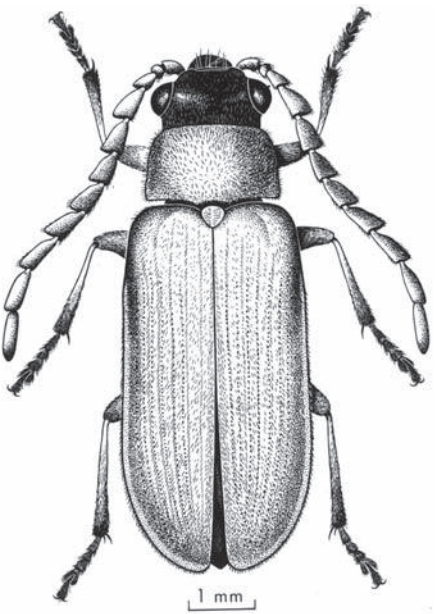
The minute beetle, *Clambus simsoni*.
Drawing: F Nanninga, CSIRO

Dascillidae

Soft-bodied plant beetles

- parallel-sided beetles, 7.5–12 mm in length
- unable to jump (no jumping mechanism on underside of thorax)
- light to dark brown
- antennae serrate/filiform
- integument soft and bearing greyish recumbent pubescence
- sides of pronotum carinate
- tarsi 5-segmented and bilobed with membranous appendages beneath

Adults of the soft-bodied plant beetles are short lived and can be found on flowers, while their scarab-like larvae live in the soil. They are C-shaped and have well-developed legs. Very little is known about their biology and it is believed that they may be associated with ants. At present only two species are known from Australia, both belonging to the genus *Notodascillus*. The genus is distributed in coastal, southern and eastern Australia from Victoria to north-east Queensland.



Notodascillus sublineatus is one of the two species of the Australian Dascillidae. It lives in coastal, northern New South Wales and coastal, eastern Queensland.
Drawing: F Nanninga, CSIRO

Rhipiceridae

Feather- or fan-horned beetles

- elongate, sides of elytra nearly parallel, 10–25 mm in length
- grey-black, pronotum and elytra with conspicuous whitish spots formed by setae
- mandibles strongly curved, prominent
- antennae of male strongly flabellate, antennae of female pectinate, male antennae with >15 segments
- antennae inserted on prominent transverse ridge below eyes
- sides of pronotum not completely carinate
- setose lobe between the claws
- tarsal formula: 5-5-5; segments 1–4 deeply bilobed, with membranous appendages beneath

The males of these medium-sized beetles resemble chafers at first glance, but have thin legs. They have large, fan-like antennae, but these are not the true scarab-like lamellate organs as they have more than 20 segments and cannot be opened and closed readily. Fan-horned beetles occur in most states of Australia, including Tasmania.

The biology of the Australian species is not known at all. Their lifecycle could provide an interesting study. Based on knowledge of the biology of one American species (*Sandalus niger*) it is presumed that rhipicerid larvae may be ectoparasitic on cicada nymphs. Adults are attracted to light at night. No larva of any Australian rhipicerid is known. Six named species in one genus (*Rhipicera*) are known from Australia. All are beautiful, delicate beetles.

The genus *Rhipicera* is distributed all over Australia with species in many types of habitat. They are not often encountered but occasionally visit lights at night. This specimen was photographed in tall eucalypt forest in coastal New South Wales.

Buprestidae

Jewel or metallic wood-boring beetles

- elongate, bullet-shaped, rigid body, 1.5–60 mm in length (occasionally longer)
- distinctive colouration, often metallic, especially on ventral surface
- head hypognathous
- antennae short and serrate, 11-segmented (except for *Castiarina antia* which has only 10 antenomeres)
- tarsal formula: 5-5-5, ventral membranous lobes on segments 1–4

The distinctive characteristics of jewel beetles make them easy to identify. However, they could possibly be confused with a few somewhat similar beetles, namely the click beetles (Elateridae), lizard beetles (Languriidae) and throscid beetles (Throscidae). The click beetles differ from buprestids by having a movable ('clicking') prothorax, while the antennae of the beetles in the other two families are usually clubbed.

Some jewel beetles mimic other insects, but their mimicry usually consists of imitating the colour and/or pattern of the model, while the typical buprestoid body shape remains. Nearly all jewel beetles are active and diurnal. Most are especially very active and alert on hot, sunny days when they readily take to the wing if disturbed, or feign death and fall (thanatosis), or fall then fly. They are phytophagous, the adults feeding on foliage, bark or the nectar or petals of flowers. Some species are important pollinators.

The larvae of most species bore into wood, but some are leaf miners, feeding

Diphucrania regalis (subfamily Agrilinae) (10 mm) lives in the coastal regions of Queensland. The larvae bore into wood; adults are herbivorous. The specimens shown here is from heath. The large genus was until recently known as *Cisseis*.

Cyrioides imperialis (subfamily Chalcophorinae) (38 mm) is widely distributed in eastern Australia. It can be found on various *Banksia* species (including *B. marginate* and *B. ericifolia*) and rarely on *Isopogon* species.[19]

inside stems or the stalks of grasses and forbs, or feed within the roots of plants. The larvae of at least one species is probably free roaming in soil. The typical buprestid larva is legless, has a small head, reduced antennae, a wide, flattened thorax, and a long, narrow body. They resemble longicorn (Cerambycidae) larvae, but are flatter. The crosscut shape of the tunnels, which the larvae excavate, is typically oval, not round as in those of most other wood-boring beetles.

The Australian fauna currently consists of 77 genera and 1205 species, most of which are endemic. Many more species await description.

This is a typical larva of a jewel beetle. It resembles those of the Cerambycidae, however it is somewhat flatter.

Castiarina macmillani (subfamily Buprestinae) (10 mm) lives on the Western Plateau of Western Australia. This specimen was photographed east of Perth.

Castiarina bucolica (subfamily Buprestinae) (14 mm) is distributed in most parts of Western Australia.

Iridotaenia bellicosa (subfamily Chalcophorinae) (22 mm) is an inhabitant of open forests in north Queensland.

Selagis viridicyanea (subfamily Buprestinae) (18 mm) is recorded from the eastern, coastal regions of Queensland and also from northern Victoria. There are no published records from New South Wales.

Members of the genus *Habroloma* (subfamily Agrilinae) (2 mm) are the smallest jewel beetles. They occur in Queensland, New South Wales, the Australian Capital Territory and Western Australia. Their tiny larvae mine into plant tissues.

The genus *Agrilus* (subfamily Agrilinae) (7 mm) is distributed all over the continent and in Tasmania. This particular specimen could be one of several species such as *A. australasiae* or *A. hypoleucas*. It was photographed in Canberra, on *Acacia*.

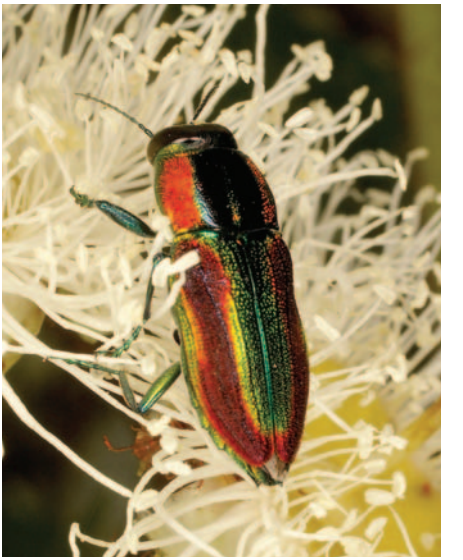
Astraeus (Depollus) aberrans (subfamily Polycestinae) is a species of inland Western Australia. Its larvae bore into wood and the adults are herbivorous. Their host plants are various casuarinas.

Castiarina carinata (subfamily Buprestinae) (14 mm) is a beetle of north-eastern, coastal Queensland. This one was photographed in a north Queensland open forest.

Austrochalcophora subfasciata (subfamily Chalcophorinae) (25 mm) is a seldom seen beetle of the Queensland rainforests.

Castiarina pictipennis (subfamily Buprestinae) (10 mm) is a Western Australian woodborer, distributed to almost all parts of the state. This specimen was seen on heath in south-west Western Australia.

Castiarina nasata (subfamily Buprestinae) occurs in Queensland, New South Wales, the Australian Capital Territory and Victoria, where it feeds on *Leptospermum* flowers. It is a mimic of net-winged beetles (Lycidae).



Selagis caloptera (subfamily Buprestinae) (15 mm) occurs in Queensland, New South Wales, the Australian Capital Territory and Victoria. Its adults feed on various flowering shrubs and trees. This specimen was photographed in a Queensland eucalypt forest.

A long life

Many jewel beetles lay their eggs into moribund trees rather than decaying dead wood. The young larvae usually tunnel into the sapwood and as they grow, they may develop a maze of passages within the tree, packed with sawdust and frass, in which they pupate.

Their complete lifecycle can take several months. However, in some species it may be several years, even decades, before the adult beetles emerge. It is not unusual to find freshly emerged jewel beetles in timber used in buildings. The eggs of these are laid in the wood before it is processed into timber. If they are lucky, they may be bypassed by the wood processing machinery and survive inside the timber. Milled timber usually is quite dry and as it seasons through age, its nutritional value diminishes too. These conditions most probably slow down the development of the larvae within and more than likely contribute toward a delayed metamorphosis.

The survival champion of the Buprestidae is the American golden jewel beetle, *Cypriacis aurulenta*. It occasionally turns up in Australia in imported wood. Its development in milled timber may take a very long time – in one of the recorded cases 51 years![22] The usual development time in the wild for this beetle is three to five years. However, the reliability of such records of delayed development can be questioned if the age of the structural timber from which the adult(s) emerged is not determined beyond any doubt. Other factors such as recent, infested timber additions to the building structure can also contribute to erroneous conclusions.

Metaxymorpha gloriosa (subfamily Buprestinae) (26 mm) is from coastal Queensland. Its host plant is *Casuarina cunninghamiana* and the adults are florivores. They were recorded from flowers of *Eucalyptus gummifera*.[21]

One of the largest Australian jewel beetles is *Temognatha grandis* (subfamily Buprestinae) (55 mm). It is found in New South Wales where it feeds on the flowers of various shrubs and trees.

This beetle belongs to the genus *Neocuris* (subfamily Buprestinae). Its specific name is difficult to determine as the genus *Neocuris* is in need of revision. This species lives in Western Australia.

Temognatha variabilis (subfamily Buprestinae) (48 mm) has many different colour and pattern variations. It is widely distributed, feeding on the flowers of various *Leptospermum*, *Angophora* and *Eucalyptus* species.

This attractive jewel beetle, *Stigmodera roei* (subfamily Buprestinae) (26 mm), inhabits Western Australia. This specimen is from heath, near Perth.

Nascio simillima (subfamily Buprestinae) (7 mm) occurs in Queensland. This specimen was found on a eucalypt tree, in northern Queensland.

A clicking jewel beetle

When alarmed, the small (8 mm) West Australian species *Astraeus fraterculus* 'clicks' like a click beetle (Elateridae). It snaps open its elytra and catapults out of harm's way. It appears to have a latch or lock mechanism on the elytra, and probably has elastin in the muscles which close the elytra. So every time it closes them they are under tension and the stored energy is released when the beetle wants to get away quickly.

It has been recorded on *Hakea trifurcata* as well as *Daviesia divaricata*.[20]

Astraeus fraterculus (subfamily Polycestinae) can 'click' like a click beetle.

Temognatha sexmaculata (subfamily Buprestinae) (55 mm) is distributed in New South Wales and the Australian Capital Territory. This rather dark specimen was seen on Putty Road, north of the Colo River, New South Wales, on *Leptospermum*.
Photo: G Hangay

Temognatha carpentariae (subfamily Buprestinae) (50 mm) is from the coastal area of Queensland.

Byrrhidae

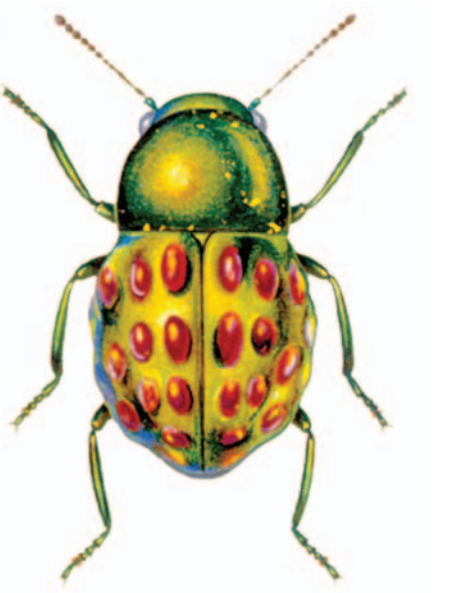
Pill beetles

- body broadly oval, convex, pill-like, black or metallic green, 1.5–5.5 mm in length
- appendages folded into ventral grooves
- head deflexed
- antennae 11-segmented, usually thicker toward the apex
- legs short and flattened
- tarsi thin, tarsal formulae: 4-4-4 or 5-5-5

As their common name implies, these small beetles when alarmed, may resemble 'pills' or rather grains of soil, gravel or tiny pebbles. They achieve this by tightly retracting their legs and head against the ventral side of their body and remain motionless until danger passes.

Adults and larvae feed on mosses, liverworts and lichens, while some species feed on the roots of higher plants. They lead secretive lives, usually inhabiting the soil under stones, leaf litter and matted clumps of the above-mentioned plants. Adult beetles come out at night to feed on the mosses, liverworts and lichens found on tree trunks and rocks.

Pill beetles favour high humidity habitats but remain active also at lower temperatures. Even on freezing-cold, sub-Antarctic Macquarie Island lives an indigenous byrrhid (*Epichorius sorenseni*). It moves around at night, feeding on mosses and lichen growing on the rocks.[23] At least one species (in Victoria) is known as termite-loving. In Australia at present there are 30 named species divided into three genera.



The Tasmanian pill beetle, *Pedilophorus gemmatus* (3 mm), has the most striking colours of this family. It feeds on mosses in rainforests.
Drawing: F Nanninga, CSIRO

Callirhipidae

Callirhipid beetles

- distinctive parallel-sided and flattened body shape, 10–20 mm in length
- resembles Rhipiceridae, but without white spots of pubescence
- mandibles short, not projecting
- antennae 11-segmented, strongly flabellate in males, pectinate in females
- tarsal segments without membraneous lobes beneath, but with setose lobe between claws
- tarsal formula: 5-5-5

Callirhipids are striking looking beetles. They appear somewhat similar to rhipicerides (see page 106) and in the past they were classified as close relatives. Their taxonomic positions have been re-examined and now they are placed in different superfamilies.

These beetles live in the coastal wet sclerophyll and rainforests of eastern Queensland and northern New South Wales. The larvae live in decaying soft wood of fallen trees and sometimes occur in large numbers. However, adults are rarely encountered, occasionally the odd specimen comes to the light at night.

Little is known about the biology of the Australian species; the information we have comes mostly from overseas sources. Only four species in two genera are known from Australia.

This specimen of the genus *Callirhipis* (12 mm) was seen in a Queensland forest. Its fan-shaped antennae make it appear very scarab-like. But while scarabaeids can fold their lamellate antennae closed, callirhipids (like rhipicerids) cannot do so.

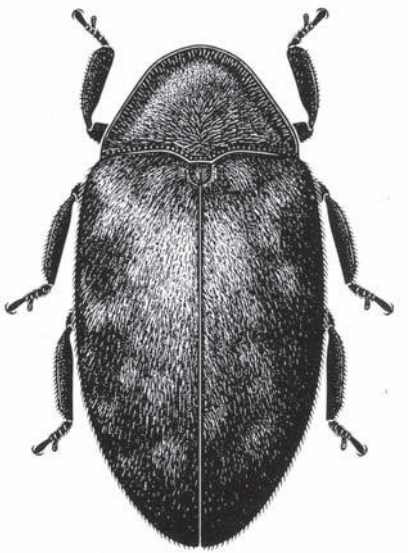
Chelonariidae

Chelonarid beetles

- highly compact, oval body, 5–6 mm in length
- head deflexed, hidden by pronotum from above
- antennae 11-segmented, weakly serrated
- antennae and legs when retracted fit into ventral depressions
- tarsi short, fourth segment strongly ventrally lobed
- tarsal formula: 5-5-5

In Australia this family is known from only one species, which is found in north Queensland. When alarmed, the small beetle retracts its antennae and legs, taking on the appearance of a dark-coloured seed.

Almost nothing is known about its biology, but the study of overseas species reveals that the family is terrestrial and some live in mulch-like leaf litter, under bark and in termite galleries of tree branches, while others are myrmecophilous. Careful fieldwork may shed more light on the biology of this interesting beetle.



Chelonarium australicum (6 mm) is the only species representing this family in Australia. It lives in Queensland. Drawing: S P Kim, CSIRO

Elmidae

Riffle beetles

- body oval, almost cylindrical, dull black to grey, 1.0–5.8 mm in length
- head deflexed
- antennae moderately long and slender, 11-segmented and filiform (subfamily Elminae) or with widening apical segments, forming a loose club (subfamily Larainae)
- mid-coxae distinctively separated
- legs long and thin, terminated by two conspicuous claws
- tarsal formula: 5-5-5

The riffle beetles, as their common name implies are aquatic, favouring unpolluted running waters, such as riffles. They can also be found in slower-flowing waters, even in ponds and lakes, and streams of the High Country.

Adults and larvae feed on waterlogged wood and other vegetation as well as on small particles of flotsam. Their long, clawed legs help them to hold on firmly to rocks and submerged logs underwater. Adults obtain oxygen from the air which is trapped in the pubescence of their ventral surfaces or through their breastplate, known as plastron. Their larvae breathe by the means of gills situated in the ninth abdominal segment.

The final stage instar leaves the water to pupate at the water's edge. After emergence, the adults re-enter their aquatic environment. As riffle beetles live only in pristine waters, they are now considered as reliable water quality indicators.

This minuscule riffle beetle of the genus *Stetholus* (subfamily Larainae) is phytophagous and prefers clean, unpolluted ponds and lakes. It occurs in eastern New South Wales and Queensland. Adults and larvae presumably live together.

Riffle beetles commonly come to light. Nine genera and 104 described species are known from Australia. Of the 104 species, 100 belong to the subfamily Larainae, formerly known as Larinae.

Heteroceridae

Variegated mud-loving beetles

- body elongate, somewhat flattened, densely pubescent, 2.2–5.3 mm in length
- dark brown, dull yellow markings on elytra
- head prognathous, mandibles and large labrum visible from above
- antennae short, with serrated, 7-segmented club
- tibiae flattened with long thin spines on the outer and apical sides
- tarsal formula: 4-4-4, without lobes

These beetles live in the wet mud or sand at the edge of billabongs, lakes, mangroves and watercourses. They construct tunnels just under the surface of the mud, marked by tiny mound-like vents and feed on aquatic microorganisms and detritus. The larvae are campodeiform with forward pointing heads and with short, 3-segmented antennae, and hairy bodies, wide at the pronotal section and tapered towards the posterior.

Heterocerids are the typical beetles of many arid and semi-arid inland regions, near bodies of water. They are strongly attracted to lights at night, sometimes in huge numbers. They are widely distributed all over the mainland, but not in Tasmania.

Eight species and two genera are known from Australia

This specimen (2.5 mm) of the *Heterocerus* genus was seen near a pond in North Queensland. The best way to see these beetles is to splash a few buckets of water on the bank of a pond or slow-flowing stream. They will come out of their subterranean homes, trying to escape the deluge and can be picked up for closer examination.

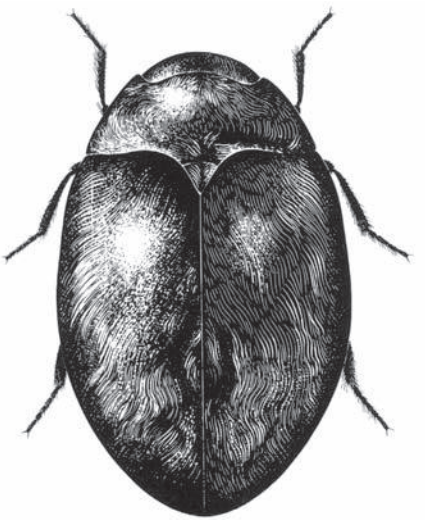
Limnichidae

Minute marsh-loving beetles

- body broadly oval, convex, 0.9–4.5 mm in length
- black, often with short, greyish or yellowish pubescence, some glabrous
- head strongly deflexed, fits into thoracic depression
- clypeus large, separated by distinct clypeal suture
- pronotum posteriorly lobed
- antennae slender, 11-segmented, filiform or with 3- or 4-segmented club
- legs fit into depressions on ventral side of body
- legs short and thin, tarsi without lobes, usually 5-segmented

These minuscule beetles look very similar to pill beetles (Byrrhidae). Their head and appendages can be folded neatly in cavities on the underside of the body, which is less convex than that of the byrrhids. Limnichids can also be differentiated from byrrhids by their large clypeus which is separated at the front by a distinct suture.

Limnichids usually live in moist habitats near streams and lakes. Adults and larvae occur in mud, sand and leaf litter, feeding on decaying vegetable matter. One genus occurs on coral reefs, feeding on algae. Adults – often in large numbers – are strongly attracted to artificial light at night. The Australian fauna comprises of nine species in two subfamilies.



This is the marsh-loving beetle *Limnichus australis* (2.2 mm). The larvae of the Australian Limnichidae are not known. Drawing: F Nanninga, CSIRO

Psephenidae

Water-penny beetles

- body oval, flattened, black or dark brown, densely pubescent, 3–8 mm in length
- head deflexed, narrowed between antennal insertions, forming a short rostrum
- eyes visible from above
- pronotum not posteriorly lobed
- antennae 11-segmented, filiform or serrate
- legs short and thin
- tarsal formula: 5-5-5, tarsi not lobed

At a cursory glance Psephenids appear quite similar to some members of the preceeding families, but a closer examination under the microscope reveals the differences. Their larvae are more distinctive, being flattened, disc-shaped, superficially resembling trilobites. Their round shape together with the fact that they are aquatic gives rise to their common name.

Water-penny beetles can be seen at night clinging to rocks and feeding on algae in lakes and streams.They spend the daylight hours in hiding. The final instar leaves the water and pupates on shore. The larvae pupate within their skin and once the pupae form, they crawl out of the larval exuviae, travel a short distance and rest for two to three weeks. During this time the imagos develop and finally emerge. Adults spend their short lives in the accumulated, dead vegetable matter on stream banks or on the nearby vegetation. After mating, females lay their eggs on submerged stones.

Sclerocyphon larvae avoid sunlight and during bright, daylight hours cling to the undersides of submerged logs and rocks, grazing on algae. They live in clean waters and therefore their presence indicates low pollution levels.
Photo: John Gooderham & Edward Tsyrlin

Water-penny beetles occur in the eastern parts of Australia and in Tasmania; one species is recorded from central Australia. Thirteen named species in one genus (*Sclerocyphon*) are known from Australia, but it seems likely that a number of undescribed species still await discovery.

Ptilodactylidae

Toe-winged beetles

- body oblong to elongate, brown, with fine, dense pubescence, 2.5–8.5 mm in length
- head mostly not visible from above
- antennae of female serrated, males pectinate, some species with articulated appendages attached to antennal segments
- elytra striate
- scutellum heart-shaped
- tarsal formula: 5-5-5; third tarsal segment usually lobed beneath, fourth segment very small

Ptilodactylids, or toe-winged beetles, are similar to callirhipids (page 114), but are smaller and without a setose lobe between their claws. Very little is known about the biology of this family of beetles.

Ptilodactylid larvae have been found in a variety of habitats, usually close to streams and rivers in leaf litter, decaying wood, and in sand and gravel. The larvae of some North American species are aquatic. Adults can be seen on waterside vegetation and they are attracted to artificial light at night.

The Ptilodactylidae is an interesting family of beetles and it is likely that more Australian species will be discovered in the future. At present five species in two genera are known from Australia.

Toe-winged beetles can usually be found near flowing water.

Brachypsectridae

Texas beetles

- body flattened, yellowish-brown, dorsal surfaces sparsely hairy, 3.5–6 mm in length
- hind angles of pronotum extended backward
- antennae 11-segmented, expanded and serrated from fifth segment to tip
- tarsal formula: 5-5-5

The characteristics listed above are related to the adult form of a species from North America, as no adult form has yet been found in Australia. The common name of these beetles originates from the USA, as they are found in Texas and adjacent states.

The larvae of one or more undescribed species, which may belong to the genus *Brachypsectra*, have been found in Western Australia, South Australia and Queensland.[24] These larvae live under loose bark and are ambush predators of spiders or other small arthropods, which they pin between the flexible head and 'tail' spine and pierce with their perforate mandibles. Larvae are 3–15 mm in length; their body is broadly ovate, strongly flattened and disc-like, with bristles, scales and hairs. Their dorsal surfaces are more or less heavily pigmented and sclerotised; generally granulate or tuberculate. The ventral surfaces are very lightly pigmented.[25]

Brachypsectra fulva is a North American species. However, Australian species are likely to be very similar. Photo: Jeffrey Gruber

Eucnemidae

False click beetles

- body elongate, compact, broadest at pronotum and tapering toward rear, 3–18 mm in length
- front end of prosternum is straight, not lobed
- head usually strongly convex between eyes, inserted into the prothorax to the level of the eyes
- antennae not close to eye, 11-segmented, moniliform, serrated, sometimes fan-shaped
- pronotum trapezoid with pointed posterior angles
- elytra striate
- tarsal formula: 5-5-5

False click beetles look very much like click beetles (Elateridae). They differ by not having a lobed prosternum and although their prothorax is freely 'hinged' to the mesothorax, they do not employ their clicking ability to right themselves, as click beetles do. Rather, they use it as a defence mechanism, to startle and ward off attackers.

The larvae are white, near cylindrical and somewhat flattened, with a very small head and no legs. Eucnemids are rarely seen in their natural habitat. They occur in forests and woodlands, where adults and larvae live in decaying wood, under the bark of dead or heavily injured trees, already under attack by other insects. They are predators and possibly also feed on slime mould. Adults are attracted to light at night.

The Australian eucnemid fauna consists of 35 genera and 90 species.

This false click beetle from North Queensland belongs to the subfamily Melasinae. It can fly well and is occasionally trapped in flight or in light traps.

Throscidae

Throscid beetles

- body oblong to elongate, somewhat flattened, resembling other elateroid beetles, brownish-black, with fine pubescence, 1.6–3.5 mm in length
- antennae very short, usually have 3-segmented club
- labrum visible

Throscid beetles look like small, stout click beetles (Elateridae) but can be distinguished mainly by their visible labrum, clubbed antennae and the absence of a transverse ridge between the eyes.

The larvae are rather soft, unlike the 'wireworm' click beetle larvae. They have small heads and reduced legs. The biology of the Australian species is not well known; most knowledge regarding the habits of these beetles come from European or North American studies. Australian throscids occur in leaf litter, in decaying wood and under the bark of trees. Adults occasionally frequent flowers and are attracted to artificial light at night.

The Australian fauna consists of 10 described species in three genera.

This unidentified specimen is a typical throscid species. Photo: R de Keyzer

Elateridae

Click beetles

- body elongate, narrow, elytra tapering toward the tip, 3–54 mm in length
- prothorax loosely joins mesothorax, can be moved individually, has sharp hind angles
- prosternum is anteriorly elongated and posteriorly has elongated process that fits into a cavity in mesosternum
- front coxae globular
- well-developed hind coxal plates
- head usually with sharp transversal ridge between eyes (absent in some)
- antennae close to eyes, at anterior margin of head, usually serrated, never clubbed
- labrum visible

The appearance of elaterids is very characteristic and their ability to 'click' is unique. Beetles of closely related families, such as the Eucnemidae and Throscidae may look similar to true click beetles, but a closer examination reveals the differences. Elaterids, in addition to the above-listed most important features, also show spherical procoxae with very much reduced trochantins and prominent hind coxal plates.

Click beetle larvae are also quite characteristic: they are elongate, cylindrical (sometimes somewhat flattened) and have a heavily sclerotised exoskeleton. They are tough and hard to the touch, hence their common name: wireworms.

The larvae of some species feed on vegetable matter, including the roots of cultivated plants. However, other elaterid larvae are carnivorous – they hunt for other insect larvae and small invertebrates. They 'inject' their digestive juices into the prey and once it turns to liquid they lap it up.

Adult click beetles may be predaceous but many are phytophagous and some frequent flowers, probably acting as pollinators.

Why and how do click beetles click? The answer is relatively simple. Click beetles usually click as a means of self-defence, but they may also click in order to get out of an uncomfortable situation – such as being unintentionally upside down.

Click beetles mostly inhabit foliage, flowers or live under the bark of trees, and when disturbed usually free-fall out of danger. For one reason or other, they often fall on their back. Their fine, short legs are of very little help on such occasions, but this doesn't worry the click beetles as they are the masters of springing back on their feet from awkward positions. They have a spine or knob-like process on their prosternum which can suddenly be snapped into a corresponding cavity of the mesothorax, causing a quick movement of the prothorax to create an audible 'click'. This sudden snap catapults the beetle in the air and, if it is lucky, it falls back on its feet. Sometimes it takes a few clicks to become upright again.

The closely related false click beetles (Eucnemidae) also use a snapping motion as a deterrent against an attacker, but not to right themsleves.

There are 70 genera and 667 described species in Australia, but many more as yet unnamed species await discovery.

This click beetle larva (10 mm) was found under the bark of a rainforest tree in North Queensland. It is most probably a predator.

The genus *Lanelater* (subfamily Agrypninae) with five known species is widespread in the northern half of Australia. This specimen (18 mm) was found in a north Queensland open forest.

The genus *Paracalais* (subfamily Agrypninae) with 21 known species is widely distributed in Australia, even on Norfolk Island, but has not been recorded from the south-west of Western Australia. This specimen (15 mm) is from a Queensland rainforest.

The genus *Anilicus* (subfamily Elaterinae) with five known species is represented in New South Wales and the eastern, coastal regions of Queensland. This beetle (6 mm) was photographed in a north Queensland open forest.

The genus *Megapenthes* (subfamily Elaterinae) with 11 known species has been found in every state of Australia except Tasmania and the Northern Territory. This specimen (14 mm) is from Sydney.

The unusually attractive click beetle *Ophidius histrio* (subfamily Elaterinae) (16 mm) occurs in coastal New South Wales and Queensland. There are another three named species in this genus. Photo: O Kelly

Lycidae

Net-winged beetles

- body elongate, flattened, 5–22 mm in length
- integumen soft, usually dorsally reddish-yellow and/or black, ventrally black,
- elytra usually broadest toward rear, dehiscent, with distinctive lengthwise ridges and less distinct cross-ridges
- head triangular or rostrate, deflexed, partially covered by front margin of pronotum
- antennae thick, flattened, serrate to pectinate, 11-segmented
- tarsal formula: 5-5-5

Net-winged beetles are usually very distinctive but can be confused with some very good mimics belonging not only to other beetle families but also to other insect orders (see pages 36–37). Some cantharids resemble them too, but the elytra of these are always lacking the ridges characteristic of the Lycidae.

To differentiate lycids from their mimics, one must examine them closely with a good magnifier or preferably with a binocular miscroscope. Their head is characteristic, the labrum is always well developed and visible, eyes are oval and very obviously convex, and almost appear as bulging. The maxillary palpi are 4-segmented and their pronotum is distinctively sculptured, divided into sections by ridges. The legs are somewhat flattened. The larvae are also elongate, more or less flattened and strongly sclerotised.

In their adult stage, members of some genera, including *Porrostoma* (formerly

This net-winged beetle larva (5 mm) from north Queensland is making an easy meal of a defenceless termite worker. Most lycid larvae feed on decaying plant matter and other detritus on the forest floor.

Porrostoma rhipidium (12 mm) is a typical net-winged beetle. The genus is widely distributed in Australia, except the very dry interior of the continent.

The genus *Trichalus* is represented by 35 species distributed over the eastern half of Australia. This specimen (7 mm) was found in north Queensland.

known as *Metriorrhynchus*) frequent certain flowers (e.g. *Leptospermum*) where they are thought to feed on nectar and pollen. They may therefore also act as pollinators. Adults live for a relatively short time. They can be seen flying slowly in forests and woodlands during spring and summer.

Larvae live in moist leaf litter, under the bark of trees. They feed upon decaying plant material and associated organisms, but may also be predators of small invertebrates. *Porrostoma* larvae have been reared on mouldy wood.[26]

The Australian fauna presently consists of 203 described species in 13 genera.

Some net-winged beetles, such as this *Porrostoma* species (12 mm), are gregarious and can be found in relatively large numbers on flowering shrubs and trees, where they mate.

Net-winged beetle mimics

Net-winged beetles are not desirable to predators. They advertise this with warning colours – usually red or reddish, often combined with black. *Porrostoma* species are especially distasteful to birds and other insectivorous animals. As well as their colour, they also have a repulsive odour and ooze a blood-like liquid when pressed. Most insect-eating animals 'know' this and therefore give a wide berth to anything that remotely looks like them.

Lycids have a whole host of mimics which, as tasty morsels for any insectivorous animal, resemble the foul tasting net-wing beetles. For example, many Australian beetles of the Buprestidae, Elateridae, Cantharidae, Lampyridae, Cleridae, Meloidae, Oedemeridae, Cerambycidae, Chrysomelidae and Belidae mimic lycids. Even insects from other orders, such as Diptera, Hymenoptera and Lepidoptera mimic them.[27]

This phenomenon is called 'Batesian mimicry' named after the British coleopterist Henry Walter Bates, who worked out the theory of mimicry that now bears his name.

However, mimicking a model by huge numbers of mimics could defeat the purpose. If the mimics outnumber the model, it could lead to a situtation where young, inexperienced predators will take the mimics first instead of the model. They would therefore not receive the desired 'training' and continue to predate on the mimic.

This tiger moth of the genus *Cyana* (Lepidoptera: Arctiidae) is one of the many moth species that mimic net-winged beetles.

Lampyridae

Fireflies or flashing fireflies

- body elongate, flattened, integumen soft, 3.5–11.5 mm in length
- pronotum usually yellowish with darker markings, elytra brownish, pubescent, often ridged lengthwise
- head entirely or mostly concealed from above by pronotum; males have large, hemispherical eyes
- antennae filiform, 11-segmented
- females of some species are wingless or larviform
- live specimens luminous, from two preapical segments of abdomen in males, one in females
- tarsal formula: 5-5-5

The common names of these peculiar insects are misleading because they are not 'flies' but true beetles. Their most characteristic feature is that they emit a faint light.

Lampyrids can be observed on warm, humid nights in wet forests, including mangroves, of northern and eastern parts of Australia. Adults are nocturnal – both sexes fly in the darkness, looking for a suitable mate. Some females don't have flying wings and their elytrae are shortened or absent. Hence they are sometimes referred to as glow-worms.

Adults most probably don't feed at all, however the larvae are predaceous, mainly hunting small snails and other, soft-bodied invertebrates, such as earthworms. They paralyse their prey by injecting, through their tubular mandibles, a secretion which breaks down the proteins in the prey's body, liquefying the tissues. The homogeneous mass is then imbibed by the larva.

The Australian Lampyridae fauna is not very rich. It consists of 25 described species in four genera.

Members of the genus *Luciola* occur in the damp forests of New South Wales, Queensland and the Northern Territory. This specimen (6 mm) is from Queensland.

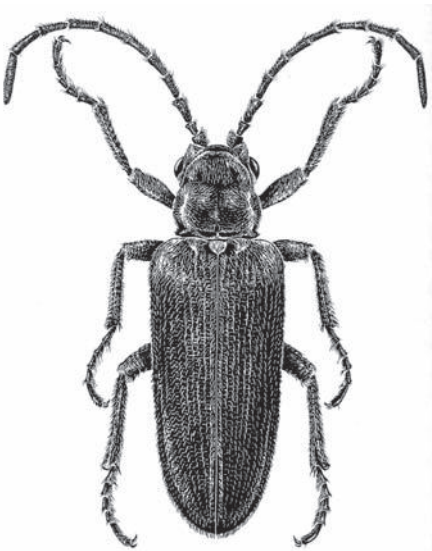
The small, hooked mandibles of this predatory lampyrid larva (8 mm) act like hypodermic needles. The larva injects its prey with a digestive secretion that liquefies its proteinous tissues.

Rhinorhipidae

Rhinorhipid beetles

- elongate, pubescent, 5–8.5 mm in length
- head strongly bent downward, antennae filiform, moderately long
- clypeus narrow, labrum membranous, elongate and concealed
- prothorax narrow without lateral carinae
- hind coxae with vertical posterior face
- claws pectinate
- tarsal formula: 5-5-5

This family is endemic to Australia and is one of the few families of beetles described in the last 40 years. It consists of a single described species found on the Tamborine Mountains and Springbrook, Queensland.[29] It was collected at the edge of rainforest, near small streams and from the foliage of the introduced, noxious crofton weed, *Eupatorium adenophorum*.



Rhinorhipus tamborinensis superficially resembles a longhorn beetle (Cerambycidae). It is a unique, rare beetle. Illustration: after Lawrence

Cantharidae

Soldier beetles

- body elongate, integumen soft, sides nearly parallel, 2.5–15 mm in length
- often vividly coloured; yellow and black, or elytra slightly metallic, bluish/greenish-black
- head usually visible from above, antennae filiform, 11-segmented
- elytra loosely cover abdomen, often reduced
- legs relatively long and flexible, abdomen soft
- male genitalia usually extruded
- tarsal formula: 5- 5-5, segment 4 bilobed

Soldier beetles got their common name because of the colours of the most common species, mostly belonging to the large genus *Chauliognathus*. These resemble the colours of the uniforms soldiers wore in some armies of the 18th and 19th centuries.

Some cantharid species are gregarious and can occur in huge numbers – another reminder of armies or soldiers. *Chauliognathus lugubris* is appropriately called the plague soldier beetle, occasionally occuring in 'plague' proportions. But apart of being a bit of a nuisance to humans, the masses of these beetles cause very little damage – if any at all.

They gather on flowers, especially those of *Leptospermum*, or on the tips of shrub and tree branches, erect, prominent objects, such as flagposts, markers and alike. These large congregations of certain species seem

Chauliognathus lugubris (subfamily Chauliognathinae) (12 mm) is frequently seen congregating on flowering shrubs and trees, such as *Leptospermum*, *Eucalyptus* and *Angophora*. Its larvae are predaceous, feeding on small arthropods.

This handsome soldier beetle, *Chauliognathus apicalis* (subfamily Chauliognathinae) (12 mm), occurs on the eastern coastal regions of Queensland from the New South Wales border to Cape York.

The genus *Chauliognathus* is widely distributed in Australia (including Norfolk Island) and also in most parts of the Americas. This specimen (11 mm) is from Queensland.

This species of *Heteromastix* (subfamily Dysmorphocerinae) (5 mm) was seen in a north Queensland rainforest. *Heteromastix* beetles prefer forests and woodlands.

The large genus *Heteromastix* occurs in most of Australia except the arid centre and the Northern Territory. This small soldier beetle (4 mm) lives in north Queensland rainforests.

to serve the mating process, as most of the specimens participating are usually coupled or actively seeking a mate.

Soldier beetles have, unusually for beetles, a soft body. Their colouring warns potentional predators that they are not palatable, even poisonous and they should be avoided. When roughly handled, some species ooze a defensive secretion containing various alkaloids, amongst them toxic precoccinelline, a substance also produced by ladybirds (Coccinellidae) as a defensive chemical.

Cantharids are predators, hunting for smaller, soft-bodied arthropods, but are also known to feed on pollen, nectar and foliage. The larvae are stout, campodeiform, clad in a velvety clothing, usually dark brown or bluish-black. They inhabit the soil and leaf litter and feed on small invertebrates. Pupation takes place in a small cell, in the moist substrata, and adults emerge in the spring and early summer.

There are about 120 described cantharid species divided into three genera in Australia.

Nosodendridae

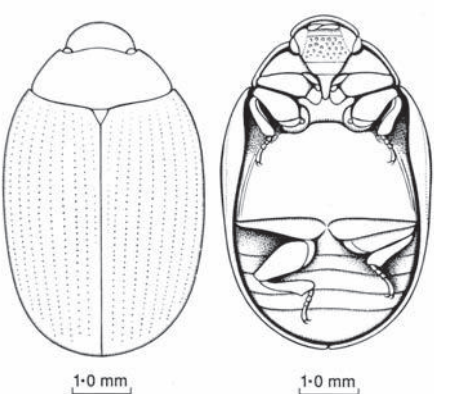
Wounded-tree beetles

- body oval, dorsally convex, black, 3.5–5.5 mm in length
- head pointing forward, not retractable
- ventral surface of the head enlarged
- antennae with distinctive 3-segmented club
- mentum forms a horizontal plate, larger than the visible section of the prosternum
- legs can be folded into cavities on the ventral surface of the body
- tarsal formula: 5-5-5

These small beetles look very much like pill beetles, the Byrrhidae, but they differ from those by having antennae with sharply defined 3-segmented clubs (the antennae of byrrhids gradually widen to the apex). The mentum appears to be larger than that of the Byrrhidae and forms a horizontal plate. The mentum of the byrrhids is small and hidden between the mouth and prosternum.

The adults and larvae of the Australian species are found under the bark of trees, in north Queensland. However, as their commmon name suggests, members of this family in Europe and North America feed on the oozing sap of wounded trees.

Three species are known from Australia, including *Nosodendron australicum*.



The wounded tree beetle *Nosodendron australicum* (8 mm). Illustration: F Nanninga, CSIRO

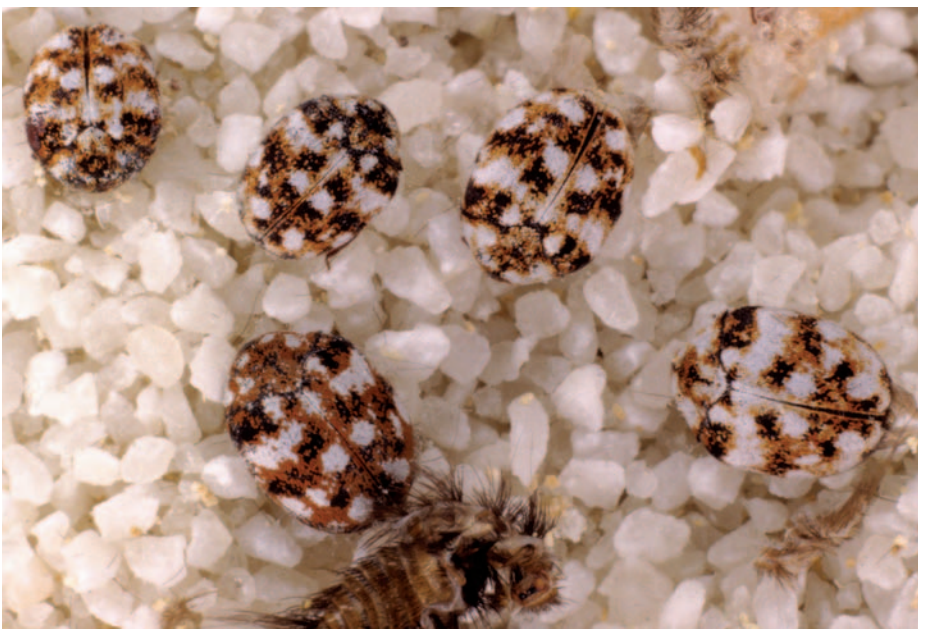
Dermestidae

Dermestid beetles

- body oval to elongate, or broadly oval to nearly circular, 1–12 mm in length
- mostly brown to black, often hairy or scaly, scales sometimes form patterns
- head somewhat concealed from above, directed downward, often with median ocellus (except *Dermestes* spp.)
- antennae short, usually fit into grooves below each side of pronotum
- antennae mostly have a 3-segmented club
- tarsal formula: 5- 5-5

Dermestid beetles have a number of other common names, mostly indicating their food preferences. They may be called bacon, hide, leather, skin, larder, warehouse, fur or carpet beetles. Among them are found some very harmful stored-goods pests. In nature, dermestids can be found on old, dry carcasses, in bird and mammal nests, while the adults of some species visit flowers, where they feed on pollen and nectar.

Dermestids are specialised to consume very dry substances, such as desiccated skin, sinews and hair. They may be found in spider webs, where they fed on the dry remains of the spider's prey, under the bark of trees and in the nests and burrows of



Species of *Anthrenus* (subfamily Megatominae) (2.5 mm) feed on the tiniest morsels of dry, proteinous matter left on the bones of a vertebrate animal or within the carcass of an insect's exoskeleton. Also known as museum beetles, they can be serious pests of any zoological collection of dry specimens. A cast-off skin of the larval form can be seen in this photograph.

insects and vertebrate animals. In these habitats they feed on organic debris, mainly of animal origin.

The larvae are more or less cylindrical, hairy and usually share the habitats with the adults. Some possess enzymes that are capable of breaking down keratin and chitin. Others are polyphagous and can eat plants, sometimes live wholly on vegetable matter. The larvae are active, voracious eaters, and clothed with dark brown hair, which act as weapons of defence. They shed their hair quite easily and the barbed or spear-headed ends get embedded in the body of an attacker.

Many dermestid species can cause huge damage not only to cereals and cured meat products but also to museum specimens of animal origin, woollen carpets and anything else that they can eat. Some dermestids are especially feared by museum curators and collectors as they can quickly ruin taxidermic

Nasty customers

One of the most dreaded dermestid beetles is the Khapra beetle, *Trogoderma granarium*. This small, brownish, inconspicuous-looking beetle probably originates from the Indian subcontinent. Despite its inability to fly, it has spread all over the world with commercial cargo. It favours a warm, dry climate, but as most ship holds, warehouses and storage areas are temperature and humidity controlled, it can now thrive indoors in colder countries too.

The Khapra beetle is a master of survival. It can endure starvation for years, hiding in the tiniest nooks and crannies, in cracks, behind peeling paint or scales of rust. A female can lay 50–100 eggs at a time, and there can be up to nine generations a year. Larvae are up to 5 mm in length and are covered with dense, reddish-brown hair.

Trogoderma granarium can destroy a huge grain storage in a short time. They are known as a 'dirty feeders', because they spoil more grain than they eat with shed larval and pupal skin, broken body parts and hair. The contaminated grain can then cause gastrointestinal problems to human consumers.

What's more, *Trogoderma granarium* is an omnivorous scavenger readily consuming a whole host of products beside grain. For instance it likes protein and feeds on anything containing animal glue, such as cardboard boxes. It is known also to damage oil paintings, soiled linen, dried animal skins and cured meat as well as herbs, peanuts, dried fruit and rice.

The Khapra beetle is not established in Australia, although specimens in incoming cargo are infrequently intercepted. Quarantine authorities such as AQIS exercise great care to prevent an infestation, which would cause extensive damage to Australia's grain industry.

Australia has a number of native *Trogoderma* species, but these are known to live under the bark of trees where they feed on dead insects.

Trogoderma variabile (subfamily Megatominae) (4 mm) is an introduced species which has become established in New South Wales and Western Australia. It is now considered to be a grain pest.

The larvae of *Dermestes carnivorus* (subfamily Dermestinae) can cause terrible damage in stored goods and museum collections. In nature they are useful 'recyclists' of dead animal tissues.

The larvae of various species of *Dermestes* (subfamily Dermestinae) (6 mm) are used to clean bones for museum collections.

specimens and insect collections. The worst offenders are *Anthrenocerus*, *Anthrenus* species, *Reesa vespulae*, *Trogoderma* species (especially *Trogoderma versicolor*) and some *Attagenus* species. *Reesa* is also a stored grain pest, and has the peculiar characteristic of being parthenogenetic.

A number of dermestid species have spread all over the world – mainly with human 'assistance', in the hold of cargo ships, air freight and even through parcel post. Most *Dermestes* species are prolific breeders. As protein scavangers they can strip a skeleton of all dried particles of skin and flesh in a relatively short time, leaving just the bones. This habit is sometimes used by museum workers to clean bones for study or display purposes. But they need to be kept in tightly closed containers in order to prevent them from dispersing, because even just a few escapees could cause terrible damage in a museum's collection. It is said that *Dermestes* can chew through timber to get to more palatable, proteinous food inside packing crates. This may be a fallacy,

This species of *Anthrenus* (2.5 mm) from Western Australia frequents flowers, presumably feeding on pollen and nectar. It is said that adult *Anthrenus* visit and feed on flowers temporarily in order to mature their eggs. Nevertheless, some species can do without this as they multiply prolifically within a closed environment, such as inside a box or drawer of an insect collection.

because all *Dermestes* species feed only on material of animal origin. However, their larvae may dig long tunnels into wood for pupation.

The Dermestidae is represented in Australia by 17 genera with 130 species.

Bostrichidae

Auger or shot-hole borers

- body cylindrical, black, reddish-brown or black and brown, 3–20 mm in length
- head directed downwards, nearly or completely concealed from above
- antennae not geniculate, 9- to 11-segmented, with 2- or 3-segmented club
- pronotum usually wrinkled, sometimes with curved, hook-like protrusions
- elytra usually marked with pits and apical spines
- tarsal formula: 5-5-5

Auger or shot-hole borers got their name because they bore small holes in wood, bamboo and other dry vegetable matter. Their larvae can cause enormous damage to timber and are also serious pests of forestry, where they bore into weakened or freshly felled trees. Larvae may survive in seasoned wood, undergo metamorphosis and emerge as adults, however, these don't reinfest the same timber. Some bostrichids are known to damage the seasoned wood of winecasks. The larvae of some species tunnel into green shoots of plants.

Members of the subfamily Lyctinae (previously Lyctidae) are known as powder-post beetles. They are reddish-brown to black, 1–7 mm in length, with narrow, flattened, nearly parallel-sided bodies. They differ from the other bostrichids by having heads visible from above (not covered by the pronotum), rows of hair on their elytra and their antennae have 2-segmented clubs. The larvae bore into dry wood, reducing it into a fine, flour-like powder, hence their common name.

Bostrichidae do not have cellulase, a digestive enzyme which breaks up cellulose in their food. They utilise starch and sugars in the sapwood they consume with the help of some endosymbiotic bacteria that lives in their alimentary canal. In their natural habitat adult and immature bostrichids can be found in moribund or dead trees in many parts of Australia, although they are most numerous in the tropics. Adults readily fly to artificial light at night.

Lyctine beetles, such as this species of *Minthea* (subfamily Lyctinae) (5 mm), are quite capable of attacking a range of hardwood trees, and infesting the starch-containing sapwood. They avoid softwood trees. The subfamily Lyctinae is represented by a number of species, some indigeneous and some introduced. Photo: CSIRO Entomology

The introduced species *Rhyzopertha dominica* (subfamily Dinoderinae) (3 mm) is a dreaded pest of silos and warehouses where it feeds on grain and various kinds of dried foodstuffs. It is especially fond of rice. It was introduced to Australia with infested imports.

The introduced woodborer *Heterobostrychus aequalis* (subfamily Bostrichinae) (6 mm) can survive in milled timber, its larvae completing their development in manufactured wooden articles. They leave tell-tale flight holes and fine frass on the surface of the timber.

The well-known *Bostrichopsis jesuita* (subfamily Bostrichinae) (8 mm) is a native auger beetle that bores into *Acacia* and *Eucalyptus*. It can cause some damage to fruit and other cultivated trees but is not considered a serious pest as it favours already injured or unhealthy trees. It occurs in most parts of Australia, except the arid, tree-less environments.

There are about 45 named species of Bostrichidae in Australia, including some introduced, polyphagous, cosmopolitan species that are serious pests of bamboo (major pest: *Dinoderus minutus*), stored goods, namely rice (major pest: *Rhyzopertha dominica*), all sorts of dried fruits, herbs, spices and wood products.

Anobiidae

Furniture and spider beetles

- body shape varies: elongated-cylindrical, oval, ovoid, 2–6 mm in length
- body surface is reddish to dark brown, clothed with fine hair
- head is concealed from above by hood-like pronotum
- antennae 9- to 11-segmented, often with last three segments lengthened and expanded
- head and appendages are contractile, appendages often fit into ventral hollows/grooves
- tarsal formula: 5-5-5

At first glance, these beetles may resemble bostrichids. The most conspicuous difference between the two families is the length and size of the antennae. Anobiids usually have longer and more 'voluminous' antennae than bostrichids – they lack the discrete 3-segmented club.

There are similarities in their life styles, as many species of anobiids are woodborers, while others are polyphagous, feeding on dry vegetable matter, leather, textiles and various other stored products.

The spider beetles (Ptininae, formerly Ptinidae), which now form a subfamily of Anobiidae, are – as their common name suggests – beetles with a spidery appearance. They are small, 2–5 mm in length, more or less globular or egg-shaped, slow-moving insects, often found in cupboards, museum displays and almost any other dry environment where they can obtain some desiccated animal and/or vegetable material. Many are myrmecophiles.

In nature anobiids prefer dry habitats also – they can be found in or under the bark of dead or moribund trees and in leaf litter. Occasionally they are attracted to artificial light at night, but never in large numbers.

In Australia there are about 189 named species in 38 genera, including a number of introduced foreign species.

This species of *Calymmaderus* (subfamily Dorcatominae) (2 mm) comes from a north Queensland rainforest. Its congener, *Calymmaderus incisus*, the Queensland pine beetle, bores into the softwood of some pines, where the larvae develop. If they survive the milling process, they complete their metamorphosis in machined timber.

The shiny spider beetle, *Mezium affine* (subfamily Ptininae) (3 mm), is not a borer but a detritus feeder. Introduced into Australia from the Mediterranean, it can become a household pest, infesting larders and stored goods. Photo: Natalie Barnett, CSIRO

A scary pest – the death-watch beetle

Some death-watch beetles bore into wood and have the habit of striking their head and prothorax against the walls of their tunnels. This is their way of signalling for a mate, a kind of a love call. The resulting knocks were interpreted by superstitious people as signs of approaching death – hence their common name.

The large European anobiid, *Xestobium rufovillosum*, which doesn't occur in Australia, is most probably the species that inspired this peculiar name but it is relatively harmless. The truly frightening pests are those which cause huge damage to stored products and other produce, not only in Australia, but worldwide. Among these the drugstore beetle (*Stegobium paniceum*) and the cigarette beetle (*Lasioderma serricorne*) are probably the best known.

The drugstore beetle is a dreaded pest of all sorts of dried produce, such as herbs, spices, and even poisonous substances. These beetles have been seen to thrive happily in a container full of the hottest chilli powders imaginable!

The aptly-named cigarette beetle likes tobacco, despite the fact that nicotine is a deadly poison to almost all insects. It doesn't eat the entire cigarette (or cigar) but drills countless holes and passages into it, rendering it useless. But they are not fussy! They have been seen to penetrate a laboratory-kept mealworm colony and chew up the walls of the timber container in which they were housed and spread right through an entire museum! They can bore into and breed in compressed woodchip panels (despite their formaldehyde content) and can damage preserved museum specimens of insects, birds and mammals, even those which have been treated with arsenic.

Because they are small and avoid daylight, drugstore and cigarette beetles are often not detected before they cause enormous damage. Because of their similar life styles, these two species are often confused. A thorough examination of their antennae and the sculpturing of the elytra reveals the difference.

Damaged caused by *Lasioderma serricorne* (subfamily Xyletininae) (3 mm).

Lymexylidae

Ship-timber beetles

- body elongate, very narrow with nearly parallel sides, 7.5–23 mm in length
- integumen soft, reddish-brown to brown
- antennae short, filiform, fusiform or serrate
- elytra either long and narrow or very short, not reaching the abdomen
- tarsus often longer than tibia
- tarsal formula: 5-5-5

Ship-timber beetles are extraordinarily slender with a distinctive shape. Members of the genus *Atractocerus* have very short elytra and well-developed, gauzy flying wings. When these beetles are at rest, their wings are folded fan-like but as the reduced elytra can not cover them, they are exposed.

Gravid females have enormously swollen abdomens. They lay their eggs in wounds of eucalypts and possibly other hardwoods too. The cylindrical and elongate larvae have short, strong legs, and a hood-like pronotum, which partially conceals the head from above. They bore into the timber and grow to considerable size (up to 35 mm in length). Their tunnels run parallel and transversally with and to the grain. Discontinuous, irregular bands of stain marks caused by their activity discolour the timber.

The larvae feed on a fungus, which grows on the walls of their tunnels in the timber. This fungus is transmitted by the beetles themselves. It is presumed that their development takes at least two years. Adults can be found in decaying timber, on tree trunks and occasionally fly to artificial lights. Adult specimens of a Western Australian species of *Atractocerus* sometimes fly in swarms at dusk.

Some species of lymexylids, because of their wood-boring activities, are considered pests of forestry and the timber industry. Their common name is an indication of the habit of *Lymexylon navale*, a European species, that bores into the hardwood timber that was used for ship-building in the past.

The known Australian fauna at present consists of 10 species in three genera. Most species are considered rare.

The two described species of the genus *Melittomma* (subfamily Melittomminae) occur in coastal Queensland and New South Wales; one of them also lives on Lord Howe Island. This specimen (12 mm) is from the rainforests of north Queensland.

Species of the genus *Australymexylon* (subfamily Melittomminae) can be found in the coastal regions of eastern Queensland and northern New South Wales. This specimen (11 mm) was photographed in an eucalypt forest, north of Sydney.

Trogossitidae

Bark-gnawing beetles

- body ovoid, dorsal surfaces with or without setae, often scaly or with flattened setae, forming a pattern, generally dark in colour, 2.3–15 mm in length
- head prognathous, visible from above
- antennae 9- to 11-segmented, with 1- or 3-segmented club
- tarsal formula: 5-5-5, but may appear to be 4-4-4

Bark-gnawing beetles are beneficial, as they prey upon wood-eating insects and their eggs. They live under the bark of trees, in decaying timber and anywhere else in wooded country where they can find prey.

Trogossitid larvae are subcylindrical or tapered towards the head, whitish in colour and share the habitats of the adults. They are predators, just like the adults, and often enter the tunnels of wood-boring insects to hunt the occupants. However, some species readily consume vegetable matter as well, especially cereals, and thus became pests of stored products. There are about 36 described species in Australia.

Tenebroides mauritanica (subfamily Trogossitinae) (5 mm) was introduced to Australia with imported products. Known also as cadelle, it is a cosmopolitan pest of cereals, cereal products and other dried foodstuffs of vegetable origin. The larva also predates on the larvae of other stored-produce insects. Photo: K V Makarov

This bark-gnawing beetle of the genus *Lepidopteryx* (subfamily Trogossitinae) (12 mm) is found under the bark of trees. There are 11 described species in this genus. This specimen was photographed on Mount Mee, about 60 km east of Brisbane. Photo: O Kelly

Cleridae

Checkered beetles

- elytra elongate, more or less parallel-sided
- upper surface with stiff bristly hairs
- head not deflexed
- pronotum usually constricted at base (narrower than elytra) and apex
- head exerted, eyes laterally prominent
- legs elongate, robust, with well-developed tarsi with one or two segments lobed
- antennae usually with loose 3-segmented club, usually much less than half the body length
- tarsal formula: 5-5-5, sometimes appearing 4-4-4

Checkered beetles are distinctive and usually easy to recognise. Most species are diurnal predators and prey on insects associated with trees, timber and bark. A number of clerids are specialised to hunt the forestry pest bark beetles (Curculionidae: Scolytinae) and therefore are recognised as beneficial insects. Others, like *Trogodendron fasciculatum*, are predators of longicorn beetles (Cerambycidae) or jewel beetles (Buprestidae). However, most species have no economic significance.

Adults are often seen on flowers and some are attracted to artificial lights at night. *Eleale* and *Phlogistus* are day active so their colouration (either brightly metallic or aposematic) likely serves as a warning to predators, or serves to confuse or dazzle predators such as birds. The cosmopolitan red-legged ham beetle, *Necrobia rufipes,* is known as a pest of stored products, especially cured meats, cheese and copra. However this beetle is also predaceous and consumes the larvae of other stored-product pests, including species of *Dermestes*.

Many clerids mimic other insects such as velvet-ants (Mutillidae) or sphecid wasps (Sphecidae). More than 90 per cent of Australian clerids are endemic. At present there are 367 named species in 51 genera.

Members of the genus *Stigmatium* (subfamily Clerinae) live under the bark of trees where they hunt for small invertebrates. This specimen (10 mm) was seen in north Queensland open forest. Its cryptically coloured patterns serve to camouflage it against the bark and sometimes against lichen-covered logs.

This genus *Phlogistus* (subfamily Clerinae) includes metallic green and blue species, usually found on flowers where they hunt small arthropods. This specimen (6 mm) (probably *P. rufipes*) is from a dry forest in north Queensland.

The genus *Phlogistus* (subfamily Clerinae) probably shares distant ancestors with *Trichodes* (widely distributed in the northern hemisphere) and the North American genus *Aulicus*. This beetle (probably *P. cribratus*) (7 mm) is quite common around Sydney.

This species of *Eleale* (subfamily Clerinae) (10 mm) is from Sydney. *Eleale* species are usually metallic in appearance and congregate on flowers to mate and feed. Some species eat pollen and obtain moisture by consuming nectar from flowers.[30]

There are about 58 described species (and two subspecies) in the genus *Eleale* (subfamily Clerinae). They frequent flowers and are well distributed in most parts of Australia. This specimen (7 mm) was found on a eucalypt flower in Western Australia.

The genus *Thriocerodes* (previously *Incorynetes*) is not well researched and identification is difficult. *Thriocerodes* species are known from all states except Western Australia; some have been collected in association with *Xanthorrhoea*.

Eleale pulcher (subfamily Clerinae) is one of the more common species of checkered beetles. It is often encountered in New South Wales, the Australian Capital Territory and Victoria.

This Western Australian species of *Eleale* (subfamily Clerinae) is on a *Banksia* flower, most likely feeding on pollen and nectar, as most *Eleale* species do. Beetles in this genus are likely to have a Gondwanan origin.

Phycosecidae

Phycosecid beetles

- body broad, convex with whitish scales, 1.5–3.5 mm in length
- head flattened with only a narrow margin visible from above (mostly hidden by convex extension of pronotum)
- antennae 10-segmented with marked, 1-segmented club
- abdomen with 5 visible sternites
- legs thin, delicate
- tarsal formula: 4-4-4

Phycosecid beetles form a very small family. They occupy a niche that is quite unpopular with other beetles – the sandy ocean beaches of north Queensland, New South Wales and south-west Western Australia. They can be found on bird and other carcasses on the strandline. It is believed that they are predaceous and most probably do not feed on carrion but on the other small organisms visiting the carcass.

Only one genus with three species is known in Australia.

Phycosecis litoralis (3.5 mm) is known from the seashores of New South Wales. It occurs on carcasses, above the high-water mark. Photo: R de Keyzer

Melyridae

Soft-winged flower beetles

- subfamilies Malachiinae and Dasytinae have different body forms
- Malachiinae body: 3–10 mm in length, elongate, flattened, often widest towards rear, apex of abdomen usually exposed and often brachelytrous, with prognathous head, antennae not clubbed, flat almost quadrate pronotum, sparsely clothed in erect setae, often brightly coloured, tarsi lobed
- Dasytinae body: 1–3.5 mm in length, ovoid, elytra covering abdomen, head deflexed, pronotum strongly transverse, antennae swollen at apex, covered in dense recumbent pubescence, dull-coloured, tarsi not lobed with segment 4 reduced
- tarsal formula: 5-5-5

Most soft-winged flower beetles are generalists/omnivores and often visit flowers where they prey upon other small arthropods and feed on pollen.

Adult melyrids resemble cantharids and previously were classified as members of the superfamily Cantharoidea. Their larvae, however, are very much like those of the Cleridae and therefore they are assigned now to the superfamily Cleroidea.

Sexual dimorphism is significant in a number of species. This is especially evident in the formation of the male antennae and in some cases in the modification of the tarsi.

One species, *Dicranolaius cinctus,* is an unusual melyrid, as it is a pest of rice plantations in New South Wales. In rice crops, the species *Dicranolaius bellulus* feeds on pollen. Feeding trials in the laboratory indicate that it could be a useful biological control

This beautiful species of *Dicranolaius* (subfamily Malachiinae) (5 mm) lives in the open forests of north Queensland where it hunts small invertebrate animals on vegetation.

agent as it feeds on a variety of food sources. It readily accepts as food the eggs and first-instar larvae of the potato moth (*Phthorimaea operculella*, Lepidoptera: Gelichiidae) and heliothis (*Helicoverpa punctigera*, Lepidoptera: Noctuidae), and also dead first-instar black field crickets (*Teleogryllus commodus*, Orthoptera: Gryllidae).[31]

The known Australian fauna consist of approximately 317 species in 13 genera.

The aposematic colours of this species of the genus *Carphurus* (subfamily Malachiinae) indicate that this beetle is poisonous.This specimen (4 mm) was seen in a north Queensland rainforest.

Also known as the red and blue beetle, *Dicranolaius bellulus* (subfamily Malachiinae) (8 mm) occurs in most parts of Australia. Adults are diurnal, hunting for insect eggs, larvae and other slow-moving insects, Its larvae live and pupate in the soil.

This tiny yellow spotted beetle (3 mm) is one of the 44 known Australian species of the genus *Dicranolaius* (subfamily Malachiinae). Like most other *Dicranolaius* species, it is a predator, and inhabits the rainforests of north Queensland.

Adult beetles of the genus *Balanaphorus* (subfamily Malachiinae) look very much like soldier beetles (Cantharidae), although their larvae are quite different. Adult similarities between these two families are the result of convergence. There are 13 named species of *Balanaphorus* in Australia.

This species of the genus *Carphurus* (subfamily Malachiinae) (8 mm) was photographed in a Queensland open forest. Many melyrids of north Queensland and New Guinea have very short elytra and thus resemble rove beetles (Staphylinidae). However, they are not related.

Nitidulidae

Sap beetles

- black or brown, some with yellowish markings on elytra
- body usually broad and somewhat flattened, 1–7 mm in length
- head prognathous
- antennae 11-segmented with 3-segmented club
- elytra infrequently short, exposing two or three abdominal segments
- tarsal formula: 5-5-5

The habits and biology of our sap beetles are not well known. Some species may be found on flowers, where they consume pollen and nectar. Others feed on various fungi, vegetable matter, especially rotten fruit and the sap of injured trees. Two species, *Carpophilus hemipterus* and *C. aterrimus*, can cause serious damage in stored dried fruit or by attacking ripe fruit in orchards. A few may be predaceous.

Some species of nitidulids frequent the nests of native bees. Species of *Brachypeplus* are scavengers and do not harm their hosts but feed on the pollen and probably also on some detritus found inside the nests. However, the introduced *Aethina tumida* is a major, destructive pest of commercial honeybees.

The Australian fauna consists of more than 120 species; 22 are known pests of stored produce or orchards.

This small nitidulid (3 mm), probably of the genus *Australycra*, was found in a north Queensland open forest.

This species of the genus *Brachypeplus* (3 mm) is found inside the nests of native stingless bees (*Trigona* and *Austroplebeia* species). The genus is distributed widely in eastern Australia.

Some species of the genus *Carpophilus* are fond of decaying fruit and the sap of trees, even if they are fermented. This specimen (4 mm) was photographed on rotten papaya fruit in north Queensland.

Silvanidae

Silvanid flat bark beetles

- body elongate, flattened, yellowish- or reddish-brown, 1.5–3.5 mm in length
- head relatively large, prognathous, and sometimes distinctively elongate
- antennae 11-segmented, thickened towards the apex or with 3-segmented club
- pronotum often with prominent front angles, margins sometimes denticulate
- elytra cover the abdomen entirely
- tarsal formula: 5-5-5

Silvanids are small beetles that usually go unnoticed even by specimen-seeking coleopterists. They are closely related to the Cucujidae and may be found under the bark of trees, in decaying timber, in leaf litter, in the tunnels of wood-boring insects and on plants. In nature they may be scavengers and feed on detritus of vegetable and/or fungal origin. However, a few species are known as noted storage pests, damaging dried fruit and vegetable products, seeds and cereals. The two genera most frequently encountered in our warehouses are *Oryzaephilus* and *Ahasverus*.

About 50 species of Silvanidae are known from Australia.

Uleiota militaris (6 mm) is from open forest in north Queensland.

This is a rather small representative of the genus *Silvanus* (2.5 mm). It scavenges under bark and in decaying logs in the open forests of Queensland. Not every silvanid species is a pest.

Like most species of the genus *Silvanus,* this one leads a cryptic life hidden under the bark of trees or in the debris of the forest floor. This specimen (4 mm) was found under bark in an open forest in Queensland.

Prolific prowlers in the store room

Members of the genus *Oryzaephilus* are omnivorous pests. They scavenge bits and pieces of animal origin, vegetable debris and some are predaceous. They usually follow other, more destructive insect pests and infest already damaged stocks. Because of their minute size they can hide in small crevices and thus escape sprays and other fumigants, allowing them to breed successfully in environments where other pests perish.

The introduced saw-toothed grain beetle, *Oryzaephilus surinamensis*, is a major pest in grain bulk stores. It damages dried fruits, nuts and various grains and cereals. It is a prolific breeder, multiplying fast and in large numbers. Eggs hatch in from three to five days and the larvae develop fully in about two weeks and pupate. Adults emerge after a week and soon begin to mate. The lifespan of the adult is about a year, during which time a female may lay about 250 eggs.

The introduced saw-toothed grain beetle, *Oryzaephilus surinamensis*, appears to be well established in Australia. This specimen is on a piece of rice cake.

Passandridae

Parasitic flat bark beetles

- body cylindrical or slightly flattened, dark brown or black, glabrous, 6–24 mm in length
- head is broad, forward projecting gular processes partially conceal the maxillae from below
- antennae are moniliform
- tarsal formula: 5-5-5, with basal segment smaller than segment 2

This is a small family with only a few representative species in Australia. The adults live under bark and in the tunnels of wood-boring insects and may be attracted to light at night. The larvae are ectoparasitic on the larvae of wood-boring insects.

Passandra heros (22 mm) is an attractive beetle that is not uncommon in north Queensland. It can be found under the bark of trees, in rotten logs and in the tunnels of woodborers, where is predates on the small larvae of some wood-boring insects, especially those of the Bostrichidae.

Cucujidae

Flat bark beetles

- body elongated, very much flattened, brown and/or black, 1.5–25 mm in length
- head prognathous and broad
- antennae usually long, filiform, sometimes clubbed[32]
- elytra usually striate, sometimes lighter in colour than prothorax
- tarsal formula: 5-5-5, 5-5-4 or 4-4-4, terminal segment long

This is a relatively small family, yet it is represented in every continent except Africa and of course Antarctica. Very little is known about the habits and biology of these beetles. It is suggested by a number of authors that they are predaceous, feeding on small invertebrates. They can be found under bark and in narrow cracks and crevices of injured or dead trees. Their very flat body seems to be adapted to these environments.

The larva of the flat bark beetle, *Platisus integricollis* (12 mm), lives under the bark of various trees. Its biology is not known.

The flat, brown cucijid beetle *Platisus coloniarius* (11 mm) is found in Queensland, New South Wales, the Australian Capital Territory and Victoria.
Photo: M Thomson

The flat bark beetle, *Platisus integricollis* (10 mm), is a widely distributed species. This specimen was photographed in north Queensland.

Laemophloeidae

Lined flat bark beetles

- body elongate, parallel sided , usually flattened, glabrous or pubescent, 1.5–3.5 mm in length
- head relatively large, prognathous with prominent mandibles
- antennae 11-segmented, thickened apically but never clubbed
- pronotum with pair of longitudinal, submarginal carinae
- elytra often carinate
- tarsal formula: 5-5-5 or 5-5-4

These minuscule beetles usually go unnoticed in nature, where they usually feed on moulds or the spores and stromata of various sac fungi (Asomycota). However, some cosmopolitan species such as those of the genus *Cryptolestes* are major pests of stored grain. The peculiar thing about these beetles is that adults cannot survive on sound, uninjured grain. They have to follow more vigorous pests, let them do the 'pioneer' work first, and only then lay their eggs in the damaged stock. The larvae are especially fond of the wheat germ.

There are about 50 described species of lined flat bark beetle in Australia.

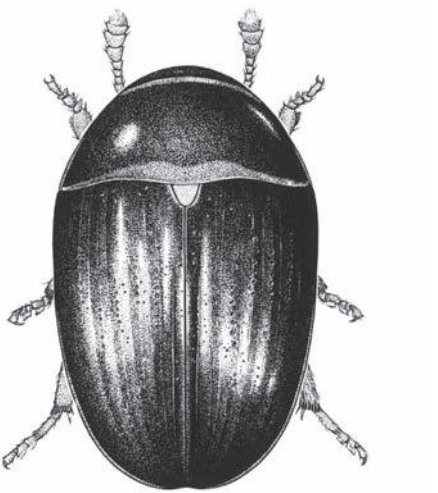
This flat grain beetle of the genus *Cryptolestes* (3 mm) can cause serious damage in stored cereals. Here an adult beetle is feeding on puffed rice.

Phalacridae

Shining flower or shining mould beetles

- body broad, ovoid, strongly convex above, flat below, glabrous, mostly brown to black, 1–3.3 mm in length
- head retracted, but partially visible from above, usually with median endocarina
- antennae 11-segmented with oval, 3-segmented club, apical segment largest
- pronotum large, emarginate in front, nearly as wide at the base as the widest part of the body
- femora enlarged and flattened
- tarsal formula: 5-5-5, sometimes 5-5-4 in males; segment 4 reduced

Phalacrids are primarily mycophagous and can be found in or near fungi with powdery spore masses and decaying vegetable matter, where they feed on moulds. *Phalacrus uniformis* was observed to feed on the spores on the galls of the fungus *Uromycladium*.[33]



Litochrus major (subfamily Phalacrinae) (3.3 mm) feeds on fungi in rotten eucalypt logs and in the debris and leaf litter at the base of large trees.
Drawing: A Hastings, CSIRO

Cryptophagidae

Silken fungus beetles

- body ovate or elongate ovate, usually light brown with short, dense pubescence, 1–3 mm in length
- head prognathous
- antennae moniliform, 11-segmented with 3-segmented club
- pronotum quadrate, sometimes with a pair of flattened knobs or teeth behind the anterior angles
- tarsal formula: 5-5-5 (sometimes 5-5-4 in males)

Adults and larvae of silken fungus beetles are usually found in association with fungi and mouldy materials. The larvae are campodeiform with forked urogomphi on the ninth abdominal segment. They often inhabit the nests of mammals, birds and hymenopterans, feeding on the mouldy detritus.

Quite a few species are considered as stored-product pests, but in reality the beetles only infest mouldy items and therefore their economic importance is insignificant. The external morphological characteristics are usually not quite enough to determine these beetles on the specific level. For definite results dissection and microscopic examination of the genitalia are necessary.

Cryptophagus tasmanicus (2 mm) most likely feeds on mould and some small fungi. It is distributed in New South Wales and Tasmania; most probably also in the Australian Capital Territory and Victoria.

Chilatomaria australis (2 mm) is an endemic fungivore species. It occurs in New South Wales.

Erotylidae

Pleasing fungus beetles

- body ovoid or elongate, dorsal surface usually glabrous, sometimes pubescent, often with bright yellow and black pattern or metallic, 2–23 mm in length
- head prognathous, deeply set into the transverse pronotum
- antennae 11-segmented with a flattened, 3-segmented club
- tibiae are usually expanded, truncate apically
- tarsal formula: 5-5-5, segment 4 usually small

Pleasing fungus beetles are associated with higher fungi, especially those growing on tree trunks and fallen logs, but also with mycelia in decaying wood. Some larvae feed on the external surfaces of fungi while others tunnel into the flesh. Adults can be found under bark or within decaying wood and during the warmer months they may be attracted to lights at night.

The family Erotylidae now includes the lizard beetles (subfamily Languriinae) previously known as Languriidae (see next page). The Australian fauna consists of more than 80 described species.

Members of the genus *Cathartocryptus* are strict fungivores. This species (2 mm) is from a north Queensland rainforest.

Neothallis wallacei (5 mm) lives in the north Queensland rainforests, where it feeds on fungi.

Erotylidae: Languriinae

Lizard beetles

- body elongate, cylindrical, glabrous black, prothorax or marks on elytra orange, 2–10 mm in length
- head prognathous, frons with a longitudinal groove above each eye
- antennae 11-segmented with a 3- or 4-segmented club
- tarsal formula: 5-5-5

In the recent past lizard beetles formed a family on their own but modern studies have shown that they should be designated as a subfamily of Erotylidae.

The shape and size of the tarsal segments are important details of the morphology of the Languriinae. The first three segments are broadly triangular and densely setose beneath, the fourth is very small (and more or less inserted in the cavity of the third) and the fifth is elongate with a simple claw.

Almost nothing is known about the biology of the Australian species, but studies of overseas languriids have shown that the larvae of some are stem-borers. The North American clover stem borer *Languria mozardi* is known to damage a variety of cultivated plants, amongst them canola (*Brassica napus*).[34]

Anadastus albertisi (6 mm) is an inhabitant of the wet tropics of Queensland, but it also occurs in Papua New Guinea. This specimen was photographed in open forest in north Queensland.

Bothrideridae

Dry bark beetles

- body elongate,cylindrical, sometimes broadly oval and somewhat flattened, mostly subglabrous, brown to black, sometimes setose, 2–20 mm in length
- head prognathous with frontoclypeal suture
- antennae 10- or 11-segmented, relatively short, usually clavate with 1- to 3-segmented club, antennal insertion exposed
- pronotum laterally convex, at least partially
- legs with apex of tibiae expanded and spinose;
- tarsal formula: 4-4-4, rarely 3-3-3

There are about 20 species of dry bark beetles in Australia, divided into four subfamilies.

Members of the Xylariophilinae feed on the fruiting bodies of pyrenomycetous fungi (Ascomycota: Sordariomycetes), while species of Teredinae live in a kind of symbiosis with platypodine weevils (Curculionidae: Platypodinae), where they inhabit the weevils' tunnels presumably feeding on the yeast – the 'ambrosia' cultivated by their hosts.

The largest bothriderid genus *Deretaphrus* (subfamily Bothriderinae) is a frequently encountered group in Australia. This specimen (5 mm) was photographed at Morven in western Queensland. Photo: O Kelly

This species of *Pseudobothrideres* (subfamily Bothriderinae) (3 mm) inhabits the rainforests of northern Queensland. It is presumed to be predaceous or parasitic, inhabiting the tunnels of wood-boring insects, hunting for their larvae and pupae.

One species in the subfamily Anommatinae, the introduced, blind and wingless *Anommatus duodecimstriatus*, lives in soil, leaf litter and subterranean wood.

Little is known of the subfamily Bothriderinae – they are predators or ectoparasites of the larvae and pupae of wood-boring beetles.

Endomychidae

Handsome fungus beetles

- body convex, brown to black, some with brighter markings, often hirsute, 2–8 mm in length
- antennae are relatively long, usually 11-segmented, including prominent, 3-segmented club
- pronotum with two lengthwise grooves/depressions at base
- tarsal formula: 4-4-4, but third segment is minute, easily overlooked

Handsome fungus beetles, as their name implies, are chiefly mycetophagous, feeding on fungi and mould. They can be found on fungi growing on trees, but also in and under decaying, mouldy logs, rotten mushrooms and damp leaf litter.

Although the larvae of the Australian species are not known, overseas studies tell that they eat similar substances as the adults and live in the same environments.

The Australian fauna consists of 12 genera and 32 species.

This specimen of *Idiopyhes* (2 mm) was found on a black fungus-covered rotten log, in a north Queensland rainforest.

The genus *Stenotarsus* is the largest genus of the Australian endomychid fauna. This specimen (4 mm) was found in north Queensland.

Encymon immaculatus (5 mm) lives in the rainforests of north Queensland.

Discolomatidae

Tropical log beetles

- body broadly oval, almost circular, somewhat flattened, subglabrous or pubescent, 1.3–2 mm in length
- antennae 9- or 10-segmented with 1-segmented club
- coxae transverse, small and globular with long internal extensions
- tarsal formula: 3-3-3

Tropical log beetles belong to the family Discolomatidae, previously known as Discolomidae. They live in forest leaf litter and under bark, possibly in decaying logs.

Larvae and adults feed on the fruiting bodies of bracket fungi (*Polyporus*) species.

This rarely seen species of *Aphanocephalus* (subfamily Aphanocephalinae) (1.5 mm) was photographed near Kuranda, north Queensland.

Coccinellidae

Lady or ladybird beetles

- body broadly ovate, highly convex, usually glabrous but some finely pubescent, 1–7 mm in length
- yellow to black, often bicoloured or spotted, some with metallic shine
- head deflexed, concealed from above by prothorax
- antennae short, 11-segmented (rarely 10- or 8-segmented), including a 3-segmented club
- tarsal formula: 4-4-4, but appears to be 3-3-3 as the third segment is minute and hidden

Ladybird beetles are very distinctive in shape and therefore most of them are quite easy to recognise. Some ladybird species are considered as pests because they damage the foliage of plants, including some cultivated ones. However, the adults and larvae of most species are predators of aphids (Hemiptera: Aphidoidea), coccids (Hemiptera: Coccoidea) and other small insects and mites (Arachnida: Acarina), and are therefore important in the control of some unwanted insects, especially scale insects (Hemiptera: Coccoidea). Some Australian ladybirds have been used successfully as biological control agents in the fight against the cottony cushion scale *Icerya purchasi*, a major pest that caused great damage to the Californian and Hawaiian citrus industries.

Ladybirds have some peculiar habits; one of them is their propensity to form huge aggregations of adults. This usually happens when the beetles have accumulated some fat reserves and stop feeding. They fly towards the highest point in their sight, usually a mountaintop, lookout point,

This species of *Cryptolaemus* (subfamily Coccinellinae) (6 mm) is eating mealybugs on citrus. Species of this genus are rather hirsute, but can be distinguished from other hairy coccinellids by their 10-segmented antennae, 3-segmented tarsi, elongated prosternum and recurved postcoxal lines on their abdomen.

This larva of *Cryptolaemus* (5 mm) was photographed in Queensland. The natural distribution of this genus ranges from Sulawesi to New Guinea and Australia, but by now it occurs in many other parts of the world due to introduction by biological control programs.

Antineda princeps (subfamily Coccinellinae) (6 mm) is an inhabitant of northern Australia. It can be distinguished from other related species by its size and orange elytra with black margins.

The tortoise-shelled ladybird, *Harmonia testudinaria* (subfamily Coccinellinae) (6 mm), is a common species of northern Australia. It is a predator, just like the other three Australian *Harmonia* species.

Rose aphids seem to be the favourite prey of the larvae of *Harmonia* species (subfamily Coccinellinae) (5 mm), but they have been seen feeding on psyllids, leafhoppers and the eggs of leaf beetles. A grown larva can consume about 50 aphids a day.

The common spotted ladybird, *Harmonia conformis* (subfamily Coccinellinae) (6 mm), occurs across the southern half of Australia in gardens and orchards, wherever aphids live. It drinks nectar from flowers and, occasionally, honeydew from aphids.

The variable ladybird, *Coelophora inaequalis* (subfamily Coccinellinae) (4 mm), feeds on a wide range of aphids and psyllids. It has been introduced as a biological control agent to mainland USA, Hawaii and New Zealand.

Coelophora mulsanti (subfamily Coccinellinae) (6 mm) is a busy predator, well suited to be a successful biological controller of aphids and other small bugs on cultivated plants. It is widely distributed in Australia.

This is *Micraspis furcifera* (subfamily Coccinellinae) (5 mm) feeding on some aphids on a rose stem. The six species of this genus are widespread in Australia. Most of them are known predators of aphids and are therefore regarded as beneficial to agriculture.

radio tower or something similar. There they form crowded aggregations, consisting of many thousands of individuals. The purpose of this seems to be to bring the sexes together, mate and then disperse.

Another interesting habit of ladybird beetles is that when alarmed they feign death and exude drops of yellow liquid from their leg joints. The fluid is toxic to vertebrates and it is assumed that it acts as a repellent towards predators.

The 'classic' ladybird genus *Coccinella* has been made well known by the European seven-spotted ladybird, *Coccinella septempunctata*, a constant and popular beetle in fairytales, poems, songs and proverbs. Two species of *Coccinella* occur in Australia: *Coccinella transversalis* is our most common coccinellid, which is also widespread in the oriental region, and *Coccinella undecimpunctata*, an introduced

This group of common spotted ladybirds, *Harmonia conformis*, is overwintering in a Kurrajong seed pod. To get protection from the elements during the cold months, they will hide just about anywhere – under bark, in cracks and crevices of injured trees, or in timber buildings and other structures. Photo: Natalie Barnett, CSIRO

Illeis galbula (subfamily Coccinellinae) (4 mm) (here with its pupa) is a fungus-eating ladybird beetle that feeds on powdery mildew (Erysiphaceae: *Odium*). Two species of *Illeis* are known from Australia.

Coccinella transversalis (*repanda*) (subfamily Coccinellinae) (5 mm) is Australia's most common ladybird beetle. There are 70 described species of *Coccinella*, most of them from the northern hemisphere.

The leaf-eating or cucurbit ladybird, *Epilachna sumbana* (subfamily Coccinellinae) (6 mm), (here with its pupa) is widespread in Australia. All species of this genus are herbivorous and feed on a variety of cultivated plants. The best way to get rid of them is to pick them off plants by hand.

This attractive ladybird beetle *Micraspis frenata* (5 mm) was photographed in Sydney.

European species, is found in Western Australia and Tasmania.

All *Coccinella* species are predaceous; their main prey animals are aphids. They also hunt other small invertebrates and occasionally feed on pollen.

In the Coccinellidae, 57 genera and 306 valid species are currently listed for Australia.

Corylophidae

Minute fungus beetles

- body broadly oval, slightly convex, surface brown and pubescent, 1–1.5 mm in length
- head sometimes concealed from above by pronotum, but sometimes partially visible
- antennae 10-segmented, including 3-segmented club
- wings narrow, fringed with hairs, venation obsolete
- tarsal formula: 4-4-4

These minute beetles often escape the coleopterist's attention. They are very difficult to spot, not only because of their small size, but also because they live in leaf litter, under the bark of trees, in rotting wood and other decaying vegetable matter. They feed on fungi, consuming their spores and hyphae.

The Australian fauna consists of 37 described species.

This minute fungus beetle of the genus *Sericoderus* (subfamily Sericoderinae) (1.5 mm) was found in mouldy hay in Queensland.

This minute fungus beetle (1 mm), belonging to the genus *Saciera*, is from the Northern Territory.

Latridiidae

Minute brown scavenger beetles

- body distinctively shaped, reddish-brown to darker brown, some speecies black, 1–3 mm in length
- antennae 8- to 11-segmented including 2- or 3-segmented club
- pronotum usually narrower than base of elytra
- elytra often striate, coarsely punctured or ribbed
- tarsal formula 3-3-3; in males sometimes 2-3-3

The name 'minute brown scavenger beetles' is somewhat misleading, as they are not true scavengers; rather they are mycetophagous, feeding on moulds and larger fungi. In the UK they also known as plaster beetles because some species are attracted to moulds growing on damp plaster.

Latridiids can be found in leaf litter, under logs and stones, in ants and termite nests, but also in damp, mouldy foodstuffs. Some species are known to inhabit dried food that has gone mouldy.

In the past this family was known as Lathridiidae, but as the original spelling of its type genus is *Latridius*, the correct name is Latridiidae. About 34 described species are known in Australia.

Aridius nodifer (subfamily Latridiinae) (1.5 mm) is common in damp food storages and has been spread worldwide by human commerce. It is easy to recognise by the bumpy ridges on its elytra – there are two humps on the third row of elytral punctures and two smaller humps on the fifth row.

Cortinicara hirtalis (subfamily Corticariinae) (2 mm) can be found on the foliage of various plants.
Drawing: F Nanninga, CSIRO

Mycetophagidae

Hairy fungus beetles

- body flattened, oval, brown, hairy, 1.5–4 mm in length
- head triangular, visible from above
- antennae 11-segmented with 2- or 3-segmented club
- tarsal formula: 4-4-4, 3-4-4 in males

As their name implies, these beetles feed on fungi, including mouldy substances. Adults and the subcylindrical larvae live in bracket fungi, mouldy leaf litter and under the bark of trees.

Some cosmopolitan species, such as *Typhaea stercorea* and *Litargus balteatus* are common inhabitants of larders and warehouses where mouldy foodstuff is stored. Some species live under mouldy straw and hay, and clumps of grass. In Australia, other *Litargus* species fall into the category of 'beneficial' insects as they have been found to be major pollinators of certain cultivated plants (at least those belonging to the family Annonaceae).[35]

Only six species of mycetophagids are described from Australia, but several more are known in collections.

This species of the genus *Litargus* (subfamily Mycetophaginae) (3 mm) was found in a north Queensland rainforest.

Ciidae

Minute tree-fungus beetles

- body cylindrical, elongate, and brown to black, 1–3.5 mm in length
- head strongly deflexed, mostly covered by frontal part of pronotum
- antennae short, 8- to 11-segmented with loose, 3-segmented club
- elytra smooth, often with short, erect bristles
- tarsal formula: 4-4-4 (almost impossible to ascertain without doing a microscopic slide preparation)

Ciids resemble Scolytinae (Curculionidae), but can be distinguished by the distinctively separated segments of their antennal club, as opposed to the compact club of the Scolytinae.

The adults and larvae of these tiny beetles are found under bark and in decaying timber, where they feed on wood-rotting fungi. Some species may occur in stored produce, but they do not damage the actual goods as they live on fungi that grow on neglected stock. A few cosmopolitan species have been detected on imported goods and intercepted by Australian quarantine authorities, but none of these seem to be established here.

Only a few species have been described from Australia; there are many undescribed species.

Members of the genus *Cis* feed on fungi belonging to the phylum Basidiomycota. This specimen (2 mm), a male, comes from New South Wales.

Melandryidae

False darkling beetles

- body elongate-ovate, brown, or dark brown, finely pubescent, 3–15 mm in length
- head deflexed, partially covered by front edge of pronotum
- antennae filiform or thickened towards apex
- elytra long and tapering into a point
- large hind tibial spurs
- tarsal formula: 5-5-4

False darkling beetles resemble true darkling beetles (Tenebrionidae, see page 177), but can be distinguished by examining their eyes and the first tarsal segment or their hind legs. The typical melandryid eye is not notched and the first segment of the hind tarsus is longer than the other three together. They also look a little like tumbling flower beetles (Mordellidae, see page 169), but melandryids differ from them by being flattened, having their abdomen completely covered by the elytra and their body not as strongly arched.

Adults and larvae can be found under bark and leaf litter. Some may visit flowers and it is said that they are active at night. There is a marked variation in size within some species, most probably caused by either the lack or the abundance of nourishment in the larval stages.

False darkling beetles live near coastal areas in eastern Australia, in Tasmania and one species occurs in the south-west of the continent. A dozen described and many more undescribed species are known in Australia.

Species of the genus *Talayra* sometimes occur in large numbers on flowering shrubs and trees, especially on lilly pilly (*Syzygium* spp.). They are active during the day too, but feign death (thanatosis) when disturbed. This specimen (3 mm) was photographed in a north Queensland rainforest.

Mordellidae

Pin-tail or tumbling flower beetles

- body boat-shaped, smoothly tapered, humpbacked, 1.5–15 mm in length
- dark brown/black, often patterned with pale spots, and pubescent patches
- head strongly deflexed, antennae with seven apical segments enlarged
- abdomen pointed, pygidium extending beyond elytra
- hind legs enlarged
- tarsal formula: 5-5-4

Tumbling flower beetles are very distinctive insects, easily recognisable by their shape and movements. They can be mostly seen on flowers but not easy to catch as they are very fast-moving beetles, jumping, tumbling or taking to the wing in a split second, at the first sign of danger.

Some species frequent dead, decaying trees and logs. While the adults seem to be nectar/pollen feeders, the larvae of various species are predatory or parasitic; others are leaf- or stem-miners of herbaceous plants.

The genus *Mordella* is distributed worldwide and can be distinguished from the other genera of tumbling flower beetles by their strongly serrated antennae.

About 113 species of mordellids are known in Australia; they occur in every state. Very little is known of the biology and their taxonomy needs extensive study.

This species of *Hoshihananomia,* with its long, pin-like pygidium, can be seen on flowers. At the first sign of danger, it either falls to the ground or flies off rapidly. This specimen (8 mm) was photographed in the Hornsby Valley, New South Wales.

Mordella leucosticta (12 mm) is one of the largest mordellids occurring in Australia. It is quite common on flowering *Angophora* and *Eucalyptus*.

This species of *Hoshihananomia* (6 mm) comes from the rainforests of northern Queensland. Like most tumbling flower beetles it is diurnal.

Rhipiphoridae

Wedge-shaped beetles

- body mostly wedge-shaped, humped and tapered, 3–30 mm in length
- brown or black, sometimes with yellow or black and brown pattern
- elytra usually long and pointed, covering abdomen
- males of some species with greatly reduced elytra, females of some species wingless
- head and pronotum strongly deflexed
- antennae usually 11-segmented, in males flabellate, serrate in females
- tarsal formula: usually 5-5-4, in larviform females of *Rhipidioides*: 4-4-4

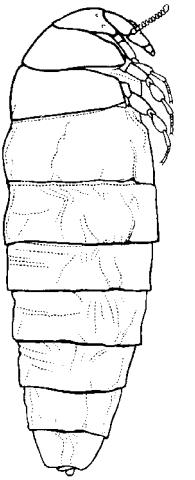
The rhipiphorids are very unusual beetles. Their larvae are parasitic of the larvae of hymenopterans, beetles and cockroaches. Adults can be divided into two distinctive groups by their appearance: one group has elytra that cover their abdomen, and the other has elytra that are greatly reduced or entirely missing.

In the subfamilies of Pelecotominae and Ptilophorinae adults of both sexes have complete elytra and their larvae are predators or ectoparasitoids of various wood-boring beetle larvae.

Females of some species in the subfamily Rhipidiinae remain larva-like all in their lives and are completely wingless,

This species of *Trigonodera* (20 mm) is one of the largest Australian rhipiphorid species. It is rarely seen during the day but is an occasional visitor to a light at night. The genus *Trigonodera* is widely distributed.

This peculiar looking tiny beetle of the genus *Rhipidioides* (subfamily Rhipidiinae) has an equally peculiar life history. It is an endoparasite of the nymphs of some blattellid cockroaches and only adult males develop elytra and wings. This specimen (3.5 mm) was photographed in north Queensland.



This adult female *Riekella australis* (subfamily Rhipidiinae) (15 mm) remains, without wings, in a larval form all her life. Drawing: F Nanninga, CSIRO

while males have reduced elytra and functional flying wings. The female lays a large number of eggs, usually on bark or at other places frequently visited by cockroaches. The newly born larva attaches itself to a blattelid cockroach nymph, pierces its integumen and becomes an endoparasite of it. Later rhipiphorid instars may change into ectoparasites, feeding externally on their host.

The smaller species of Rhipiphoridae could be confused with Strepsiptera. These peculiar insects were once considered beetles but now form their own order. Rhipihorids, unlike Strepsiptera, are true beetles of course, and don't have stalked eyes and their wings are not fan-like. The adults are short-lived, they emerge, mate and die in a relatively short time.

Adults (except the wingless females of some species) can be found sometimes on flowers during the day. They are not collected often and therefore regarded as rare in most places. Lights attract a few species at night.

About 60 described species of Rhipiphoridae are known from Australia. They occur in every state.

Zopheridae: Zopherinae

Ironclad beetles

- body parallel-sided, flattened, more or less oblong, heavily sclerotised 25–30 mm in length
- surface with deep pits and prominent tubercles, dull black or dark brown
- tarsal formula: 5-5-4

The most characteristic and best known species of this subfamily is the ironclad beetle, *Zopherosis georgei*. It is a very distinctive, easy to recognise beetle. Almost nothing is known about its biology and is considered quite rare. Adults may feed on fungi but can also be found on the trunk or under the bark of trees, mostly eucalypts. Its larvae are unknown.

The ironclad beetle may be diurnal, as it can also be seen out in the open, on the trunks of trees during the day. It is thought to inhabit mainly northern New South Wales. However, it has been also collected further south, usually in old eucalypt forests.

Zopherosis georgei (subfamily Zopherinae) (25 mm) is the largest species in the family Zopheridae.
Photo: R de Keyzer

Zopheridae: Colydiinae

Colydiine beetles

- body cylindrical or usually flattened, elongate, usually dark brown or black, 2–12 mm in length
- surface dull, sculptured or with longitudinal ridges
- head with grooves below eyes for reception of antennae
- antennae usually with distinctive, 2- or 3-segmented club
- tarsal formula: 4-4-4

Colydiine beetles can be confused with some small darkling beetles (Tenebrionidae) but the later usually have a tarsal formula of 5-5-4 and their antennal clubs are usually gradual as opposed with the abrupt clubs of the Colydiinae. However, just to make things more difficult, some very small tenebrionids do have tarsal formulae of 4-4-4. Undoubtedly, a comparative collection of correctly determined specimens would be invaluable for a worker trying to identify these small beetles.

Most Colydiinae are fungivores and live under bark or in decaying wood, sometimes in tunnels of other wood-boring insects. Some live in ants' nests. Others may be carnivorous, preying on small arthropods, mostly on the larvae of woodborers or are ectoparasitic of cerambycid and buprestid larvae. Some adults fly to lights at night.

There are members of this family over almost all of Australia, but very little is known about their biology. There are about 160 described species.

This species of *Pseudendestes* (3 mm) is a predator of platypodine weevil larvae. It hunts its prey in the weevils' tunnels. It was found in north Queensland.

This elongated bark beetle of the genus *Pycnomerus* (6 mm) was found in a forest near Coffs Harbour, New South Wales.

Beetles of the genus *Bitoma* are usually found in fallen logs on the forest floor. This specimen was photographed in a Queensland rainforest.

Ulodidae

Ulodid beetles

- antennae with distinct club
- antennal insertions visible from above
- first three ventrites fused
- elytra at base much broader than prothorax at base
- tarsal formula: 4-4-4 or 5-5-4

Ulodid beetles, both adults and larvae, seem to feed on the soft, fruiting bodies of various fungi.

The taxonomy of this group has been reorganised several times during the past two decades. Ulodidae was once a subfamily (as Ulodinae) of Zopheridae. Australia and New Zealand are the centres of diversity of the group. There are six genera and about 30 species in Australia.

Like all ulodids, this species of *Ganyme* is fungivorous. It feeds on the soft, fruiting bodies of a number of fungi. This specimen (7 mm) is from Tasmania.

Meryx rugosa (8 mm) feeds on fungi and can be found under bark, or at night, walking on the trunks of trees. Beetles in this genus have a tarsal formula of 4-4-4. Drawing: F Nanninga, CSIRO

Tenebrionidae

Darkling beetles

- body diverse in shape and colour, sometimes with metallic reflections, but mainly dull brown or black, 2–35 mm in length
- head usually with antennae inserted below lateral edges of head
- antennae mostly moniliform, sometimes clubbed, generally 11-segmented, rarely 10- or 9-segmented
- eyes usually deeply indented by antennal insertions
- upper surfaces often tuberculate or ridged, also may be endowed with diverse sculptured patterns
- legs cursorial, protibiae often adapted for digging
- tarsal formula: 5-5-4, rarely 4-4-4

Most darkling beetles are relatively large and 'interesting' looking, even for the non-coleopterist. Some are easily confused with ground beetles (Carabidae), mainly because they appear similar and often share the same environments (e.g. under logs or rocks). However, a closer examination quickly reveals the differences. In Carabidae the first abdominal segment is divided by the hind coxae, while in Tenebrionidae it is not. Their tarsal formula is different too: ground beetles' is 5-5-5. Most darkling beetles are slow moving and phytophagous, fungivorous or detritus feeders, while carabids are generally carnivorous. But resemblances with other families are quite common also, and it is said that there are hardly any groups of beetles that wouldn't share some similarities with the Tenebrionidae – at least in appearance.

The biology of this diverse family is just as varied. The archetypical tenebrionid develops in rotten wood and the adult feeds on decaying vegetable matter – but mainly fungi. Through the course of evolution many variations on this theme have evolved.[37] Many tenebrionids have departed from their fungivorous habits and can be found on flowers and foliage of a great number of plant species, and some have become symbionts in the nests of vertebrates and insects. Some are regarded as agricultural pests, damaging the root systems of cultivated plants, while others are harmful inhabitants of dried food and grain stores. They seem to have adapted rather well to Australia's semi-arid and arid environments, where surface feeding adults are mostly nocturnal in their habits in order to avoid exposure to daytime heat. The usual source of food of arid zone inhabitants seems to be dry detritus of vegetable or animal origin, seeds and other plant matter.

The inclusion of the long-jointed bark beetles (Lagriinae) and the comb-clawed beetles (Alleculinae) as subfamilies, made Tenebrionidae the fifth largest beetle family in Australia, currently numbering about 1600 species, 208 genera and 8 subfamilies.[38] About 15 000 species of Tenebrionidae are distributed worldwide. The family's probable relatives in the temperate zones of South America may indicate the family's Gondwanan origin.

Tenebrionidae: Lagriinae

Long-jointed bark beetles

- body yellowish-brown or dark blue or green, or black often with a metallic reflection, 4–16 mm in length
- head prognathous
- antennae filiform, apical segment as long as the three preceding segments
- prothorax semi-cylindrical, narrow
- elytra much boarder than prothorax, widest in the apical half, uniformly punctured and setose (not adeliines)
- legs long
- most species develop in decaying plant matter, adults on foliage

Ecnolagria rufescens was originally recorded from Tasmania. This specimen (15 mm) was photographed near Hornsby in New South Wales. The eight species in the genus *Ecnolagria* are distributed nationwide.

Lagria cyanea (7 mm) was photographed in north Queensland in open sclerophyll forest. There are nine described species of the genus *Lagria* in Australia.

Tenebrionidae: Tenebrioninae

True darkling beetles

- body shape, colour and size most diverse, 2–35 mm in length
- labrum usually transverse or subquadrate
- antennae with simple sensilla or with complex sensoria
- elytra with 9 or 10 striae

Nyctozoilus vittatus (15 mm), is a denizen of inland mallee country. This specimen is from Inglewood, Queensland. The larvae of this genus probably live in the soil, but their biology needs to be studied in more detail. Photo: O Kelly

Nyctozoilus hardcastlei (14 mm) is another arid zone species from Quilpie, south-west Queensland. There are 71 named species of *Nyctozoilus* in Australia.
Photo: O Kelly

Most of the species of the genus *Pterohelaeus* are adapted to life in arid conditions. Many of them are regarded as major root and seedling pests. This winged species (15 mm) is from a sclerophyll forest in Queensland.

Pterohelaeus is a large genus of piedish beetles with 92 named species, widely distributed nationwide. This specimen (4 mm) is from Western Australia, just north of Perth.

The confused flour beetle, *Tribolium confusum* (3 mm), is a major pest of cereals and other dried foodstuffs all over the world. Flour infested by *Tribolium* smells pungently sour and will not rise as readily as it should.

Some species of the genus *Gonocephalum* may cause damage to crops, especially where litter from previous seasons is allowed to accumulate on the ground. This specimen (7 mm) is from New South Wales.

Most *Amarygmus* species are handsome, often vividly coloured beetles. They hide under bark during the day but at night they come out to walk around on the ground or to climb up into the foliage. The larvae live in decaying wood. This specimen (9 mm) was seen in north Queensland.

There are only six known species in the genus *Toxicum* in south, east and north Australia. They develop in the fruiting bodies of higher fungi, but adults of some species can be found under bark. This specimen (9 mm) was found under the bark of an ironbark (*Eucalyptus* sp.) in north Queensland.

Most of the 18 Australian species of *Gonocephalum* are mainly inland-dwelling beetles. Their larvae develop in the soil, feeding on the roots of various plants, while adults are phytophagous and general detritus feeders. This specimen (5 mm) is from outback Queensland.

There are about 54 named species of *Amarygmus* in Australia, mainly distributed through New Guinea, the Wet Tropics and coastal Queensland and New South Wales. This specimen (8 mm), probably *A. morio*, is from a north Queensland rainforest.

Members of the genus *Cyphaleus* are associated with decaying vegetable matter and can be found in rotten wood or in moist leaf litter. Adults may be nocturnal and spend the day in hiding. This beetle (22 mm), probably *C. planus,* was seen in north Queensland.

The genus *Titaena* has 10 Australian species, occurring in southern and eastern Australia. Related genera in New Zealand, New Caledonia, the sub-Antarctic islands and southern South America indicate a Gondwanan origin. This specimen (7 mm) is from a rainforest in northern Queensland.

The 48 described species of the genus *Helea* are the 'classical' Australian piedish beetles. They are well adapted to life in the arid zone and can survive long periods with very little or no water. The larvae inhabit the soil; the scavenging adults are usually nocturnal, feeding on seeds and detritus, including dead arthropods. This specimen (14 mm) was photographed in south-west Western Australia.

Tenebrionidae: Alleculinae

Comb-clawed beetles

- body elongate to oval, brown, black and/or with metallic reflections, 4–19 mm in length
- head prognathous
- antennae filiform, last segment is not unduly elongated (unlike Lagriinae)
- prothorax narrow, distinctly marginated
- elytra striate
- legs long and slender, tarsi pectinate

The typically prognathous head of this species of genus *Euomma* is clearly visible. The genus is widely distributed in Australia. This specimen (7 mm) is from Galston Gorge, north of Sydney.

The nine species of the genus *Nocar* is distributed across Australia. This specimen (5 mm) is from northern Queensland.

The pectinate claws of this *Aethyssius* species help it to maintain a safe foothold on the plants it frequents. There are 55 known species of *Aethyssius* distributed across Australia. This specimen (7 mm) is from the Hornsby Valley, near Sydney.

Species of the genus *Aethyssius* are frequent visitors to flowering *Angophora, Eucalyptus* and *Leptospermum*. Their mouthparts seem to be adapted to harvest pollen from the flowers. This specimen (7 mm) is from Sydney.

Tenebrionidae: Diaperinae

Diaperine beetles

- body shape diverse, but generally stout, convex, ovoid or semi-spherical, 1.5–13 mm in length
- fungivorous, phytophagous, detritus feeders
- some myrmecophilous[39]

This Queensland species, *Leiochrodes suturalis* (3 mm), was seen in a wet-tropical rainforest. Its biology is not known but, judging by its leaf beetle-like appearance, it may be a foliage browser.

Tenebrionidae: Stenochiinae

Stenochiine beetles

- body elongate, usually stout, colour diverse, 6–18 mm in length
- some are the most colourful Australian tenebrionids

Species of this genus *Omolipus* are known from Queensland, New South Wales and Western Australia. This specimen (16 mm) was seen in Mt Kaputar National Park, New South Wales. Photo: G Hangay

The genus *Promethisis* is widely distributed from Indonesia, through New Guinea, Queensland, New South Wales, Victoria, to Tasmania and Lord Howe Island. This specimen (18 mm) is from Sydney.

Oedemeridae

False blister beetles

- body elongate, parallel-sided, exoskeleton soft, uniformly covered by fine, decumbent hair, 7–18 mm in length
- head moderately deflexed, usually as wide as pronotum
- antennae long, filiform
- prothorax is constricted behind, without lateral margins
- tarsal formula: 5-5-4, penultimate tarsal segment lobed ventrally

Some false blister beetles are easily confused with the meloids, the 'true' blister beetles (see page 184), but the latter usually have a broader head with a narrow neck. Oedemerids also look somewhat similar to Cerambycidae, but their tarsal formulae separate them quite easily.

False blister beetles develop in moist wood, commonly in driftwood, but also in stumps, fallen logs, dry stems of herbaceous plants and various kinds of rotting timber. Adults visit flowers and feed on pollen, others eat fungi, and some are probably predators, preying on small arthropods. However, the adults of some species may not eat at all.

Nacerdes melanura (subfamily Nacerdinae) is a cosmopolitan species that damages the timber of ships and wharves.[40]

Beetles of the genus *Sessinia* (subfamily Oedemerinae) are toxic; their body may contain cantharidin. Those with aposematic colouring may serve as models in mimicry complexes. This specimen (12 mm) was encountered in Sydney.

Copidita pachymera (subfamily Oedemerinae) (6 mm) is a small, but handsome oedemerid beetle. It is a forest dweller, where its larvae most probably develop in dead wood with white rot. This specimen was found in a Queensland rainforest.

False blister beetles may be attracted to light at night. The biology of the Australian species is not fully researched yet but overseas studies have shown that some larvae can survive in timber completely submerged underwater.[41] The Australian oedemerid fauna consists of 85 described species.

Agasma sp. (subfamily Nacerdinae) (14 mm). The biology of this genus is not fully researched yet. It is believed that the larvae develop in moist, decaying timber in the rainforest or in wet sclerophyll forests. This specimen was photographed in the Lamington National Park, on the Queensland/New South Wales border.
Photo: O Kelly

Meloidae

Blister or oil beetles

- body elongate, exoskeleton soft, leathery, some finely pubescent, 7–18 mm in length
- head relatively large, broad, and usually wider than pronotum, with narrow 'neck'
- antennae filiform or moniliform, usually 11-segmented
- colouration is diverse, ranging from reddish-yellow to greenish, bluish-black and black; head, pronotum and elytra not necessarily of the same colour
- tarsal formula: 5-5-4, claws pectinate

Blister beetles resemble false blister beetles (oedemerids), but their head is larger and they have a narrow, neck-like shape where it joins the prothorax. The Australian species are parasitoids of bees.

The lifecycle of these beetles is very complex. Mated females lay their fertilised eggs on flowers that are frequented by bees. Once the first, agile instar emerges from the egg, it hitches a ride on a bee and penetrates its nest, to feed on bee larvae, pollen and nectar. After going through several moults and instar stages, the larva's body compacts to form a coarctate instar that enters an immobile resting stage. It then metamorphoses into a different-looking pre-pupal grub that soon begins to pupate in the host's nest. The emerging adults disperse in order to find a mate and thus the lifecycle begins again.

This is a flower-visiting species of the genus *Zonitis* (subfamily Zonitinae) (14 mm). More than likely it is a pollen and nectar eater, and is quite common around Sydney, where it was photographed.

This species of *Zonitis* (subfamily Zonitinae) is a typical representative of the family. It has a broad meloid head and the characteristic pinched-in neck. This specimen (14 mm) is from a rainforest in North Queensland.

The genus *Zonitis* (subfamily Zonitinae) is widely spread across Australia. This specimen (14 mm) was photographed in Western Australia.

Palaestra foveicollis (subfamily Zonitinae) (14 mm) is a perfect example of mimicry. The model it mimics is the highly toxic and therefore unpalatable common lycid beetle *Porrostoma rhipidium*. It is found in Sydney.

Australian adult blister beetles can be found on flowers and foliage of a variety of bushes and trees. The family is represented Australia-wide with about 60 species, mostly in the genus *Zonitis*.

Mycteridae

Palm and flower beetles

- body elongate, parallel-sided flattened, yellow, reddish-brown to dark brown, finely pubescent, 2–8 mm in length
- head prognathous
- antennae filiform
- tarsal formula: 5-5-4

This small family of relatively rare beetles is distributed worldwide and the Australian fauna consists of 20 described species. Adults can be found under the bark of trees and in leaf axils or dead fronds of monocotyledonous plants.[42] Occasionally they can be collected by flight intercept traps or aerial netting, usually at dusk. Larvae are not well known, although it is said that they live with the adults.

Trichosalpingus is the most diverse genus in the mycterid subfamily Eurypinae (formerly known as Lacconotinae). Adults live under bark but also can be found on the foliage of trees. This specimen (4 mm) was found in a north Queensland rainforest.

Salpingidae

Narrow-waisted bark beetles

- body shape is diverse, mostly elongate, flattened, with sparse setae (except densely pubescent *Elacatis* spp.) 1–5 mm in length
- head prognathous, sometimes rostrate
- antennae gradually thickened towards apex
- prothorax contracted towards base
- tarsal formula: 5-5-4 (4-4-4 in *Ocholissa* spp.)

Narrow-waisted bark beetles are mostly small species, usually found on foliage and flowers, under bark and in moss. The larvae live hidden under bark or in dead wood, but some species feed on phloem, the live, nourishment-conducting tissues of plants.

The known Australian salpingid fauna presently consists of about 30 named species.

Members of the genus *Ocholissa* (subfamily Prostominiinae) are distinguished from other salpingids by their 4-4-4 tarsal formula. Almost nothing is known about their biology. This species (3 mm) is not uncommon in various types of forests in north Queensland.

Anthicidae

Ant-like flower beetles

- body slender, smaller species ant like, brown, black, or red, pubescent, 1.5–12 mm in length
- head sharply constricted at base to form a neck
- antennae filiform or clavate, or thickened apically, 11-segmented
- pronothum widest at front, constricted near base, sometimes with large horn-like process extending over the head
- elytra often with coloured pattern
- tarsal formula: 5-5-4, penultimate segment bilobed

Ant-like flower beetles (as one would expect) superficially resemble ants. Several species appear to be ant mimics and many of them (not all species) frequent flowers. The habits of these beetles are diverse; they occupy various niches in nature. Some live in damp plant debris, such as the bits and pieces of vegetable matter that accumulate after floods, but also in arid areas, near streams and ponds, even in salt marshes.

Their biology is virtually unknown, it is believed that many species are scavengers of dead insects and their larvae develop in the soil, feeding on vegetable matter.

At present, about 200 species of Anthicidae are known from Australia.

The genus *Lemodes* (subfamily Lemodinae) is endemic to Australia. This conspicuous specimen (3 mm) is not really ant-like, but probably an aposematic beetle, living in the rainforests of north Queensland.

The genus *Anthicus* (subfamily Anthicinae) has a worldwide distribution. The larvae live in soil and damp leaf litter. Adults can be found under logs and rocks. This specimen is about 4 mm in length.

The genus *Ictistygna* (subfamily Eurygeniinae) contains some handsome, yet unnamed species, such as this larger-than-usual anthicid beetle (8 mm). It was photographed in north Queensland.

Aderidae

Ant-like leaf beetles

- body shape resembling Anthicidae, yellowish to dark brown, pubescent, 1.5–3 mm in length
- head deflexed, wide as pronotum, narrower at base
- antennae filiform, sometimes slightly thickened apically
- pronotum narrowed to base, where it is narrower than base of elytra
- elytra sometimes with paler or darker spots or bands
- tarsal formula: 5-5-4, penultimate segment reduced, antepenultimate lobed ventrally

Not much is known about the habits of the Australian Aderidae, but it is said that they develop in rotten wood as larvae and adults can be found there. They also occur under bark, in leaf litter, but also out in the open, as they can be netted from foliage and are frequently captured by flight intercept or Malaise traps.

There are about 100 described species known from Australia.

Megaxenus termitophilus (4.5 mm) is a very large aderid from a north Queensland rainforest. It is an unusual species for its family, as its larvae and adults lack mandibular mola, the larvae urogomphi and they live with *Microcerotermes* termites in a trophalactic relationship.[43]

Scraptiidae

False flower beetles

- body oblong to elongate, flattened, parallel-sided to fusiform, integument soft and delicate, pubescent, 2–5 mm in length
- head strongly deflexed, eyes pubescent, large
- antennae filiform, 11-segmented
- pronotum constricted anteriorly
- legs very long with conspicuous apical tibial spurs
- tarsal formula: 5-5-4

False flower beetles look very similar to false darkling beetles (Melandryidae, see page 168). However, they have larger eyes, covering the sides and some of the ventral parts of the head, and their legs are longer. They are also similar to scirtids in that they are delicate and fall apart easily if roughly handled.

The larvae develop in rotting wood while adults can be found on foliage and frequently on flowers.

False flower beetles are represented throughout the world. The 25 described Australian species mainly occupy the eastern, coastal areas from Queensland to Tasmania. Their biology is basically unknown and there are a number of unnamed species awaiting discovery and description.

This is a species of *Scraptia* (subfamily Scraptiinae) (4 m) from a rainforest near Kuranda, north Queensland.

This species of *Scraptia* (subfamily Scraptiinae) (4 mm), photographed in a north Queensland rainforest, holds its head in an unusual, forward-pointing manner. *Scraptia* is distributed worldwide.

Cerambycidae

Longhorn or longicorn beetles

- body distinctive, elongate, cylindrical, subcylindrical or flattened, often pubescent, colour diverse, 5–80 mm in length
- head exposed, prognathous or hypognathous
- antennae usually 11-segmented, rarely with 10 or more than 20 segments, at least two-thirds of the body in length, often much longer, inserted on prominences on the emargination of the eyes
- eyes usually kidney-shaped
- mandibles often enlarged, prominent
- pronotum usually moderately convex
- elytra usually covering abdomen, most species are fully winged
- tarsal formula: 5-5-5, mostly appearing 4-4-4 (pseudotetramerous tarsi)

Longhorn beetles are easily recognisable by their long antennae and distinctive, elongate body shape. The larvae of most longhorns are woodborers. Their host plant – mostly trees and shrubs of various kinds – may be living or decayed, although most species are quite choosy and feed on certain species of plants only. The larvae are waxy white or yellowish-white, with small heads and more or less enlarged (swollen) thoracic segments. Their legs are small or absent.

Some adult species chew into bark and wood, others feed on foliage, pollen and/or the resinous sap of injured trees. None of them are predators. Flower-visiting species are important pollinators as their usually pubescent bodies carry pollen from flower to flower. While some cerembycids are regarded as major pests of forestry and horticulture, they play an important role in forest ecology by helping the decomposition of moribund and dead trees.

The Australian fauna presently has about 1250 named species. This large and important family has been neglected by taxonomists in the past and, as a result, the only catalogue dealing solely with the Australian genera and species was published in 1947.[44]

Sceleocantha pilosicollis (subfamily Prioninae) (22 mm) lives in the eucalypt forests of south-west Western Australia. A related species, *S. glabricollis* occurs in coastal New South Wales, where it breeds in *Acacia cunninghamii*.[45]

Brephilydia jejuna (subfamily Prioninae) (50 mm) occurs in rainforests and wet sclerophyll forests of Queensland and New South Wales. This specimen was photographed in north Queensland.

A giant among the Australian longhorns, *Xixuthrus microcerus* (subfamily Prioninae) (75 mm) is a denizen of the far north. This specimen was photographed in a Cape York rainforest.

This *Aphiorhynchus* species (subfamily Cerambycinae) (9 mm) with its aposematic colouring is an inhabitant of the rainforests of north Queensland. It is probably a woodborer like most other cerambycids.

The aposematic colouring of this north Queensland *Clytus* species (subfamily Cerambycinae) (7 mm) imitates a wasp. Predators familiar with the effective self-defending capabilities of wasps stay away from this otherwise defenceless beetle.

This delicate longhorn *Syllitus rectus* (subfamily Cerambycinae) (10 mm) visits *Angophora, Eucalyptus, Leptospermum* and *Syzygium*. A number of *Syllitus* species develop in *Acacia*.[46] This specimen was photographed near the Colo River, New South Wales.

Species of the genus *Hesthesis* (subfamily Cerambycinae) are excellent wasp mimics. They have reduced elytra and the second pair of wings imitate hymenopteran wings. This specimen (14 mm) was found on *Angophora* in the Blue Mountains, north-west of Sydney.

The flower or tiger longicorn, *Aridaeus thoracicus* (subfamily Cerambycinae) (16 mm), is a terrific wasp mimic. It not only looks like a wasp but also moves like one and flies readily when alarmed. The species is distributed in Queensland and New South Wales.

The genus *Uracanthus* (subfamily Cerambycinae) has 39 described species. Many of them are pests of agriculture and horticulture, including fruit such as citrus, litchi, peach, plum and apricot. This species (18 mm) is from Western Australia.

The pittosporum longicorn, *Strongylurus thoracicus* (subfamily Cerambycinae) (26 mm), is found in Queensland, New South Wales and Victoria. Its larva can effectively 'ringbark' the branch of its host plant, *Pittosporum*, causing the branch to drop off. This specimen is from Galston Gorge, near Sydney.

Species of the genus *Phoracantha* (subfamily Cerambycinae) are widely distributed, not only in Australia, but also in many other parts of the world where eucalypts have been introduced. Some species are regarded as serious forestry pests. This specimen (15 mm) was found in Sydney.

Didymocantha gracilis (subfamily Cerambycinae) (15 mm) is a rarely encountered beetle of north Queensland rainforest. Its huge compound eyes probably indicate that it is a nocturnal beetle. The raised, erect antennae lend this longhorn a most peculiar appearance.

The life of a longhorn

The poinciana longicorn, *Agrianome spinicollis,* one of our finest prionine longhorns, occurs in Queensland, New South Wales, the Australian Capitol Territory and also on Lord Howe Island. An occasional visitor to lights at night, it stridulates loudly when alarmed, but is quite harmless. It can, however, deliver a painful bite if handled carelessly.

Despite its common name, this beetle is truly polyphagous. Its larvae can happily live in a great variety of trees, introduced or native alike. Ornamental and fruit trees (e.g. citrus), various eucalypts and *Angophora* species and other native plants are all suitable as host plants.

The larvae grow to a considerable size during their two to four years of development, and can consume the entire inside of a tree or a log. The larvae are one of the several insect larvae that are known as witchetty grubs.[48] They are regarded as highly nutritious, protein-rich and tasty 'bush tucker'.

Through its entire life as a larva, the longhorn keeps chewing, digesting and growing. The byproduct of its activity, the frass, is tightly packed behind the larva. When the time for pupating arrives, it simply stops. Thus the tunnel terminates in a dead end, and the larva is sealed in from behind with the frass. This bunker-like enclosure within the interior of a tree or a log defends the insect against parasites and predators.

Within the dormant pupa, all external components of the beetle are clearly visible. The integument is not very hard and provides little protection to the very soft, almost jelly-like insect within. Immobile and defenceless, the pupa is extremely sensitive to any outside interference. The slightest injury, such as the smallest puncture, cut, tear through the exoskeleton, pressure, sudden rise or drop of temperature and humidity can deform or kill the metamorphosing beetle.

The adult poinciana longicorn. Photo G Hangay

A larva.

A dormant pupa. Photo G Hangay

An emerging imago. Photo G Hangay

Stenoderus suturalis (subfamily Cerambycinae) (9 mm) is a flower visitor, feeding on pollen and nectar. It is common on flowering lilly pilly (*Syzygium* spp.) and other shrubs and trees. It occurs in Queensland and New South Wales. This specimen was seen near Putty, New South Wales.

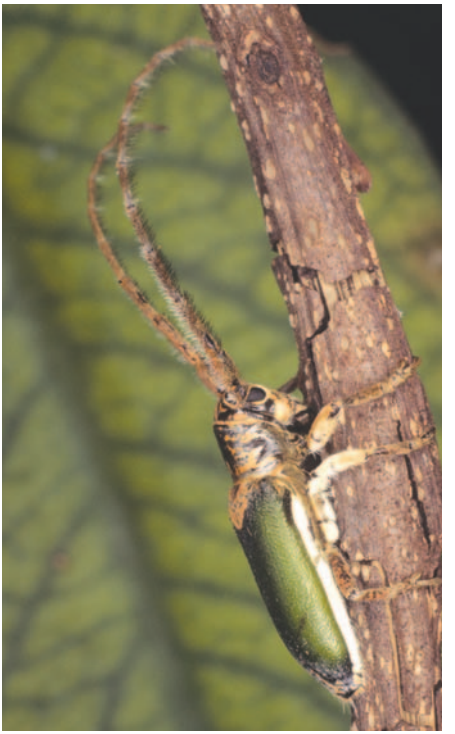
This handsome cerambycid *Rhytiphora albospilota* (subfamily Lamiinae) (26 mm) was found in a rainforest on Cape York, Queensland. Almost nothing is known about its biology, but species of *Acacia* are recorded as host plants of other species of the same genus (*R. rubeta* and *R. polymita*).[47]

Ceraegidion dorrigoensis (subfamily Lamiinae) (21 mm) from wet forest areas of north-east New South Wales is easily recognised by the protruding spines on its elytra. Photo: G Hangay

Pelargoderus arvensis (subfamily Lamiinae) (18 mm) is a north Queensland rainforest species, which also occurs in Papua New Guinea. Its biology is unknown. This specimen was seen on Cape York Peninsula.

The great fig tree borer, *Batocera boisduvali* (subfamily Lamiinae) (50 mm), inhabits the rainforests of northern New South Wales and Queensland. Its larvae bore into the trunk and larger branches of native fig trees *(Ficus* spp.).

The well-developed mandibles of *Batocera boisduvali* are well suited to chew into bark and wood. The great fig tree borer feeds on the sap oozing from injuries of the bark.



The leopard longhorn, *Penthea pardalis* (subfamily Lamiinae) (20 mm), is a borer of *Acacia*, mainly the black or hickory wattle *Acacia mangium*. Its original home is north-east coastal Queensland, western Papua New Guinea and the Maluku Islands, but it has also spread to overseas *Acacia* plantations, where it causes considerable damage.

Left: There are not too many predominantly green longhorns in Australia, but *Platymopsis nigrovirens* (subfamily Lamiinae) (14 mm) is one of them. Its colour and its cryptic posture provide a perfect camouflage on the vines of climbers. This specimen was found near Cairns, Queensland.

This species of *Microtragus* (subfamily Lamiinae) (15 mm) is a desert-dwelling longhorn, an inhabitant of inland Queensland. It demonstrates a stance, typical of many desert beetles, elevating its body away from the hot sand. This specimen was found in Windorah, Queensland. Photo: O Kelly

Chrysomelidae

Leaf beetles

- body shape diverse, usually robust, often brightly coloured, often spotted, striped, also metallic, 1–30 mm in length
- head prognathous or hypognathous, some deflexed
- antennae rarely extending past middle of body, filiform, moniliform,weakly serrate or thickened apically, with no pronounced 3-segmented club
- elytra usually covering abdomen
- tarsal formula: 5-5-5, but appears 4-4-4 (pseudotetramerous), or 4-4-4 (Cassidinae), or 3-3-3 (one species)

The leaf beetles form one of the largest families of beetles. Worldwide it has about 33 000 named species divided into 11 subfamilies, but it is estimated that a further 10 000 species still await discovery and description.

Chrysomelids occur throughout Australia, including Tasmania, Norfolk and Christmas islands, with approximately 2250 described species, 188 genera and 10 subfamilies. The adults of most Australian species feed on the foliage of angiosperms, mainly *Eucalyptus* and *Acacia*. Some, such as the cylindrical leaf beetles (Cryptocephalinae) feed on flowers, while others, such as the kangaroo beetles (Sagrinae) are pollen eaters.

Leaf beetles occupy almost all habitats where there are flowering plants and have developed so many different forms and habits that it is virtually impossible to give a short and generalised description of this family that would fit all its members. The habits and biology of the larvae are also very diverse.

The following pages give a description of the eight largest of the 10 subfamilies occurring in Australia. One group of chrysomeloid beetles, the Megalopodidae, used to be classified as a subfamily (Megalopodinae) of Chrysolmelidae, but now it has been elevated to family level. The Australian fauna consists of only a very few rare species of this family and therefore it has not been included here.

In older works Cassidinae and Hispinae were treated as two distinct subfamilies of Chrysomelidae. However, currently they are combined into one great subfamily, under the name of Cassidinae. It is indeed a big group, numbering more than 5500 species in 350 genera worldwide, but it is small in Australia, with about 54 species in 15 genera. A number of species have been introduced to Australia from South America as biological control agents for lantana. Sadly, they proved to be quite unsuccessful and instead they are now acting as hosts for native parasitoids. The subfamily Cassidinae is distributed right through the continent and adjacent islands. Because the two main components of this subfamily, known as ‘cassidoids’ and ‘hispoids’, appear to be quite different, short descriptions and examples of each are given on pages 199 and 200.

Chrysomelidae: Bruchinae

Seed weevils

- body ovoid, compact, clothed with recumbent hairs, often with spotted pattern, 2.5–5.5 mm in length
- head deflexed, covering prosternum and fore coxae; eyes deeply emarginated on front
- antennae 11-segmented, gradually thickened towards apex, often serrate, not reaching beyond base of elytra
- elytra short and broad, with rounded apices and distinct striae
- pygidium large and exposed
- hind femora swollen, with at least one ventral tooth
- tarsi with basal segment elongate

Despite their common name, these beetles are not weevils (Curculionoidea) and not even closely related to them. However, as some species are pests of peas and beans, their habits somewhat resemble some of the true weevils of which some are also pests of the same plants and their dried, stored seeds.

Seed weevils lay their eggs on seeds or seed pods, mostly of plants that belong to Leguminosae, Palmaceae and Convolvulaceae. The larvae enter a seed, develop within, pupate, and the imago emerges after a short time. The whole process may take place in one single seed.

The larvae are scarabaeiform and the pupa is enclosed in a smooth-walled cocoon. The imago chews its way out to the open, visits various flowers and feeds on pollen.

The Australian native fauna has about 20 species of Bruchinae while 10 have been introduced as biological controllers for weeds. Another three or four species were introduced accidentally and they are regarded as pests of stored seeds.

The cowpea weevil, *Callosobruchus maculatus* (3 mm), is an introduced pest of dry stored food, here stored peas. The males have spines on their intromittent organs that puncture the female reproductive tract during mating. Obviously this hurts the female and she tries to get rid of her suitor by kicking him. Entomologists believe that the spines have evolved to serve as anchors during copulation; the harm they cause is a side effect of a male adaptation.

This palm seed weevil of the genus *Pachymerus* (6 mm) is one of a number that live in the rainforests of north Queensland. This specimen is feeding within a large seed.

Chrysomelidae: Cassidinae
(Cassidoid group)

Tortoise beetles

- body oval, almost circular in outline, glabrous, often brightly coloured with pearly and/or metallic refelections
- head covered by explanate front edge of prothorax
- elytra very broad with explanate margins

Tortoise beetles are found throughout mainland Australia, but the southern species are small and rare. They are usually very pretty, often vividly coloured insects, but their colours soon fade after death and therefore preserved specimens look rather dull if compared with live ones. They are external feeders of Convolvulaceae.

The spiny larvae and the conspicuous adults can be found on foliage and a few species may visit lights at night.

This north Queensland species of *Emdenia* (6 mm) demonstrates the wide, explanate prothorax and elytra of the tortoise beetles, shielding their entire bodies.Only the antennae can be seen from above.

This north Queensland tortoise beetle of the genus *Emdenia* (6 mm) is a characteristic member of the 'cassidoid' group. Adults and larvae feed together on the surface of a leaf. A shed larval skin can be seen to the right of the centre of the picture.

This attractive species of the genus *Laccoptera* (5 mm) comes from the dry forests of Chillagoe, north Queensland. Its elytra are richly sculptured and seem to be more heavily sclerotised than most tortoise beetles' exoskeleton.

Chrysomelidae: Cassidinae

Spiny leaf beetles

(Hispoid group)

- body slender, often with distinctive spines or coarse sculpture (except *Notasacantha*, which is round, without distinct spines)
- head hypognathous but not covered by pronotum, frontoclypeus and labrum not visible from above
- tarsal formula: 4-4-4 (without minute penultimate segment) or 3-3-3 (*Leucispa*)

The adults of these leaf-mining beetles are relatively easy to recognise, especially those species with conspicous spines. They occur throughout Australia.

Adults can be found on foliage while the larvae feeds mainly of monocotyledonous plants, and some are associated with *Acacia*. They pupate on or near the ground, on or close to their host plants.

Aproida balyi (10 mm) lives in Queensland and New South Wales on the wombat berry (or twining wombat vine) *Eustrephus latifolius*. Curiously, it mimics a green grasshopper. This specimen was found on Mt Coot-tha, Brisbane. Photo: O Kelly

The conspicuous leaf-miner *Hispellinus multispinosus* (4 mm) is widely spread throughout Australia. Often abundant at the edge of woodlands, it can occasionally be seen sitting on the stems of grasses or in flight at the edge of forests or scrublands. Its larva causes blotch mines on grass leaves.

The lantana leaf beetle, *Octotoma scabripennis* (4 mm), was introduced to combat the noxious weed *Lantana camara*. The larvae mine the leaves of the plant while adults feed on the surface. However, the beetle has suffered attacks by predators and parasites, such as spiders and hymenopterans, eventually reducing its numbers.

The masterfully cryptic appearance of the larva of *Aproida balyi* is outstanding. When it pupates, it carries the mimicry even further by hanging down on the shrivelled skin of the last larval stage, mimicking a flower bud of its host plant.
Photo: O Kelly

The introduced coconut hispine beetle, *Plesispa reichei* (7 mm), is believed to be endemic to New Guinea and parts of Indonesia, but has spread to the coconut growing areas of South-East Asia, some Pacific Islands and tropical Australia. It feeds of the leaves of a variety of palms.

Chrysomelidae: Chrysomelinae Chrysomelin leaf beetles

- body oval, dorsally viewed usually appears nearly circular and convex, rarely elongate-robust, 1.5–20 mm in length
- antennal insertions widely separated and placed on anterior margin of head

Chrysomelines form the largest subfamily of Chrysomelidae in Australia, numbering about 700 described species. They are generally foliage browsers; adults and larvae feed externally on the leaves of a variety of plants, including those of the wet forests and rainforests. However, eucalypts and wattles of the dry forests are favoured by most species.

The eucalypt paropsine beetle, *Paropsis atomaria* (8 mm), is a widely distributed species, found along the Dividing Range of eastern Australia. Adults and larvae feed on eucalypts and occasionally cause significant damage to plantations in New South Wales and Victoria. Photo: O Kelly

These *Paropsis* (9 mm) larvae are protected by a chemical defensive 'weapon' – the eversible glands of their abdomens. The glands contain hydrocyanic acid, a strong toxin that deters most would-be attackers. Photo: O Kelly

The red-blue banded paropsine beetle, *Paropsis obsoleta* (8 mm), feeds on the foliage of eucalypts and has a wide distribution. This specimen was found in Queensland, where it is rather common.

The genus *Dicranosterna* is related to *Paropsis*. The globular larvae (7 mm) and the colourful adults feed externally on the foliage of their food plant, usually a species of *Acacia*.

This brilliantly coloured leaf beetle *Paropsisterna nobilitata* (6 mm) lives in the dry sclerophyll forests of Tasmania.

The aposematic colours of *Phyllocharis hilaris* deter predators. This specimen (7 mm) is from north Queensland.

The genus *Paropsisterna* is widely distributed throughout Australia with about 122 species. They feed mainly on *Eucalyptus* but also *Acmena*, *Agonis*, *Angophora*, *Baeckea*, *Callistemon*, *Darwinia*, *Kunzea*, *Leptospermum* and *Melaleuca*.[49] This specimen (6 mm) was found near Perth, Western Australia.

Despite its vivid colouration, the green strip leaf beetle, *Calomela pallida* (6 mm), can blend into its surroundings surprisingly well. It lives on *Acacia*. Once the larva reaches its final instar stage, it simply drops to the ground and pupates just under the surface of the soil.

Species of the genus *Paropsisterna* can cause considerable damage to eucalypts, especially in plantations. This specimen (7 mm) was found on eucalypt foliage in north Queensland.

The clustering, gregarious larvae of this *Phyllocharis* species (6 mm) find a safe place from predators and feed on the underside of a leaf. Photographed in north Queensland, near Cairns.

Chrysomelidae: Criocerinae

Shining leaf beetles

- body rather stout, without spines, glabrous, shiny, 3–11 mm in length
- head prognatheous, with cruciform grooves and usually deeply indented eyes
- pronotum without defined lateral longitudinal edges, narrowed in middle
- elytra striate

This is a small subfamily of Chrysomelidae and the Australian fauna consists of a few species only. Most of them are associated with monocotyledonous plants, especially grasses and orchids, while some feed on various plants belonging to the Solanaceae and Cycadaceae. Shining leaf beetles can stridulate quite loudly, what is rather unusual for leaf beetles. They generate the sound by rubbing their elyta against minute striae on the last tergite.

The dendrobium or orchid beetle, *Stethopachys formosa* (5 mm), is a serious pest of orchids in Queensland and New South Wales. It favours warmer climates and also breeds in hothouses where pest control is neglected. Otherwise it is mostly active during the warmer months of the year. Photo: O Kelly

Chrysomelidae: Cryptocephalinae Cylindrical leaf beetles

- body robust, near cylindrical, often brightly coloured and/or with metallic reflections, 1–10 mm in length
- head deflexed
- pronotum and elytra often sculptured
- scutellum usually minute or apically elevated
- female has hollowed apical ventrite

The host plants of the Australian leaf beetles are chiefly *Eucalyptus* and *Acacia*. A number of species feed on flowers. The females coat their eggs with excrement in order to camouflage them, then drop them on the ground where the hatching larvae dig themselves into the leaf litter.

Their habits differ a little from many other chrysomelids, because they develop in the leaf litter, skeletonising dead leaves and feeding on the bark of twigs. Some, however, may feed on living plant tissue.[50]

The wet tropics has many colourful species of *Aporocera*. This species (6 mm) comes from north Queensland, where it lives on *Eucalyptus*.

This species of the genus *Aporocera* (5 mm) was photographed in Sydney, feeding on *Angophora*. *Aporocera* is a large genus with more than 150 species, distributed widely in Australia.

There are more than 234 species in the genus *Ditropidus* in Australia. They are found throughout the continent. This specimen (3 mm) was seen in a north Queensland rainforest.

Chrysomelidae: Eumolpinae Oval leaf or leaf monkey beetles

- antennae separated at base by at least 2.5 × socket widths
- elytra generally non-striate; antennae generally long and simple; front femora often ventrally toothed
- female without hollowed apical ventrite

Oval leaf beetles feed on leaves, flowers and fruits of many different plants, but most species are associated with *Eucalyptus* and *Acacia*. The beetles lay their eggs in the soil or on their host plants. The larvae feed on roots and remain in the soil to pupate. Adults usually emerge after the first rains of the season, and some species often form large groups. A few species are economically important pests of agriculture.

The genus *Geloptera* is another relatively large genus of eumolpine beetles with 43 described species in Australia. This specimen (8 mm) was found on *Eucalyptus* in Queensland.

Only eight described species of the genus *Alittus* are known in Australia. These specimens (5 mm) in north Queensland are mating on a eucalypt leaf.

There are about 111 species in the genus *Rhyparida,* distributed widely in Australia. Some are regarded as agricultural pests, damaging sugar cane and other crops. This species (8 mm) lives in Queensland rainforest. It is a gregarious beetle, occasionally appearing in groups.

Colasposoma sellatum (8 mm) is a pest of sweet potato, *Ipomoea batatas,* in northern Queensland. The adults damage the stems and foliage and larvae feed on the tubers. The only representative of its genus in Australia, it occurs in the Northern Territory, northern Queensland and also in New Guinea.

Chrysomelidae: Galerucinae Galerucine and leaf flea beetles

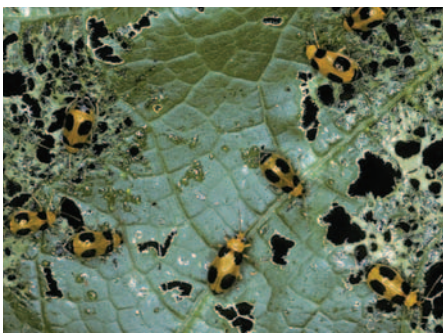
- body ovoid, elongate, 1–17 mm in length
- hind femora not swollen, adapted to walking (galerucine group)
- hind femora swollen, adapted to jumping (alticine group)

This is the largest chrysomelid subfamily, with more than 12 000 species in 1000 genera worldwide. The Australian fauna comprises of about 60 genera and 450 described species but it is envisaged that these numbers will considerably grow as studies advance. The large number of species is also due to the fact that Galerucinae now includes the flea beetles (they used to form the now synonymised subfamily Alticinae). There are about equal numbers of the galerucine and alticine species in Galerucinae. They can generally be differentiated by the simple ability of jumping: the former group cannot do so while the latter can. They feed on a huge variety of plants, chiefly on eudicotyledonous flowering plants.

Adults feed on foliage, chewing numerous small holes in the leaves. The eggs are laid on the food plants or in the soil. The larvae are usually stem or leaf miners, but some are external feeders while others feed on the root systems of plants. The subfamily is represented in almost all habitats and areas of Australia.

Monolepta oculata (5 mm) is known as a defoliating pest of some cultivated plants. The specimen was found in northern Queensland.

Quite a few species of *Monolepta* are major pests of agriculture. *M. australis* is known to attack an array of plants, including citrus trees, maize, lychees, longans, legumes, stone fruit and even pasture grasses. The larvae feed on root systems. This specimen (4 mm) is from northern Queensland.



Aulacophora hilaris (5 mm) is known as the pumpkin beetle as it damages the foliage and flowers of cucumber, melon and pumpkin. It occurs in the coastal regions of east and north-east Queensland and also in eastern New South Wales.

Chrysomelidae: Sagrinae

Kangaroo beetles

- body distinctive, elongated, pronotum much narrower than elytra, 12–30 mm in length
- head elongated, usually with cruciform grooves and deeply indented eyes
- hind femora swollen and usually with a strong tooth or ridge on the ventral face

Ten of the world's 12 genera and 33 of the 74 known species of the Sagrinae occur in Australia. They are most diverse in the arid and semi-arid zones, but also occur in heathland and woodland almost throughout the continent (except Tasmania).

Most sagrine leaf beetles are brilliantly coloured, although most Australian species are dull. Their shape is very distinctive and easily recognisable. Some species have strongly thickened hind femora, giving rise to the sometimes used vernacular name kangaroo beetles, although despite these 'muscular-looking' femora, sagrines can't jump.

Adults frequently visit flowers where they feed on pollen. Very little is known of the biology of these beetles. Members of the genus *Sagra* are stem miners of saplings and pests of certain introduced trees.

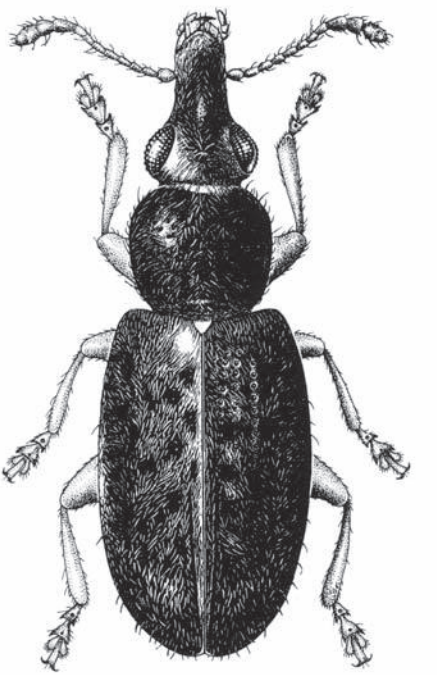
Mecynodera coxalgica (14 mm) is one of the three described species of its genus. It occurs in the coastal areas of New South Wales and is relatively common on various flowers, mainly *Leptospermum*, *Eucalyptus* and *Acacia*.

Nemonychidae

Pine flower weevils

- body somewhat elongated, flattened, with decumbent hairs and few erect hairs, 2.5–5.3 mm in length
- rostrum long and thin, not deflexed under body
- antennae not elbowed, inserted at middle or near apex of rostrum
- labrum exposed, appears as a tiny separate segment to the clypeus
- maxillary palps distinct at apex of rostrum, projecting
- pronotum without lateral carinae
- all ventrites free
- pygidium concealed

This is a small family of primitive weevils. Prior to the 1990s Nemonychidae was thought to be represented only by two species in Australia, until thorough studies revealed 14, but all are rarely seen.[51] The Australian species live on *Araucaria* and *Agathis*. Their main food is pollen, while the larvae develop in the male cones of their food plants and pupate in the soil.



This pine flower weevil is an unidentified species.
Drawing: A Hastings

Anthribidae

Fungus weevils

- body robust, generally barrel-shaped, 1.5–20 mm in length
- head with broad, flat rostrum or rostrum absent
- antennae not elbowed, with 3-4-segmented club, sometimes extremely long and thin in males
- palpi flexible but small and usually hidden from above
- pygidium exposed
- first four abdominal ventrites fused
- tarsi appear to be 4-4-4 segmented, but actually the tarsal formula is 5-5-5

Most anthribids feed on fungi or decaying plant matter, and the larvae develop within dead wood, although some are associated with the fruiting bodies of pyrenomycetous fungi (Ascomycetes: Pyrenomycetes). Some species of the subfamily Choraginae feed on seeds, while unusually for the Anthribidae, *Anthribus* feeds upon soft scales (Coccidae). More than 150 described species are known from Australia.

There are eight described species in the genus *Basitropis* (subfamily Anthribinae), but there are many more unrecorded species in Australia. Most species seem to inhabit the warmer parts of northern Australia. They are attracted to mercury vapour lights at night, but otherwise nothing is known about their habits and biology. This (3 mm) species was seen in a north Queensland rainforest.

The genus *Taburnus* (subfamily Anthribinae) of only four known species is represented in Queensland, New South Wales, Victoria and South Australia. The adult beetles appear to be bark grazers.[52] This specimen (9 mm) was found in north Queensland.

Belidae

Belid weevils

- body elongated, slender, parallel-sided, with fine decumbent hairs, 5–23 mm in length
- antennae thickened apically, not elbowed
- rostrum prominent and elongate, not deflexed below body
- labrum not distinct, gular sutures short, palps inconspicuous and rigid
- pronotum without lateral carinae; ventrites not fused
- elytra long; pygidium concealed; fore coxae large, projecting
- fore femora generally enlarged and tibiae often with teeth/comb of bristles on inner edge
- tarsal formula: 5-5-5, but appearing 4-4-4

The main distribution regions of this family are the continents and islands which once were part of Gondwana. Australia is rich in belid weevils: more than 175 described species are known from here.

The adults of most species can be seen on flowers and feed on pollen, while some larvae are known to feed on flower buds or fruit, the larvae of most species bore into wood, especially of *Acacia*. Wood-boring belids are not considered major forestry pests, because they usually attack already diseased trees. As frequent visitors of flowers, belid weevils are important pollinators.

Rhinotia species are associated with *Acacia*. The host plant of *Rhinotia brunnea* (subfamily Belinae) (10 mm) is *Acacia decurrens*. It blends into its surroundings well despite its bold pattern and colouring. Not all species are mimics. This specimen was found in Canberra.

This species of the genus *Rhinotia* (subfamily Belinae) is part of a mimicry chain, with the lycid *Porrostoma* as the model. More than 80 species of this genus are known from Australia. This specimen (10 mm) was found in an open sclerophyll forest in Queensland.

The weevils of the genus *Rhinotia* (subfamily Belinae) are rather beautiful, yet they have escaped the specialist's attention and very little is known about their biology and distribution. This mating pair (9 mm) were photographed in north Queensland.

Attelabidae

Leaf-rolling weevils

- body oblong, subglabrous or finely pubescent, some with erect hairs, 1.4–7 mm in length
- antennae not elbowed, inserted near the base of rostrum
- if rostrum long and thin front femora normal sized, elytra generally not distinctly striate
- if rostrum short and fat front femora enlarged, elytra generally strongly striate
- labrum not visible,maxillary palps significant, labial palps sometimes greatly reduced
- prothorax much narrower than elytral base
- pygidium partly or completely exposed
- first three or four abdominal ventrites fused
- tarsal formula: 5-5-5, but appearing 4-4-4

The Attelabidae is a large weevil family, incorporating more than 2000 species worldwide, including Rhynchitinae. More than 100 named species are known from Australia. While the leaf-rolling habits of overseas species have been often studied and recorded, there is not much known about the biology of the Australian species.

The genus *Euops* belongs to the Attelabinae subfamily – the 'true leaf-rollers'. One species, *Euops falcata*, is known to roll the leaves of *Eucalyptus macrorhyncha*.[53] The beetles (3 mm) shown here were seen in north Queensland.

Brentidae

Straight-snouted weevils

- body either elongate, flat and parallel-sided, or convex and pear-shaped (*Apion*, *Nanophys,* etc.), mostly subglabrous, sometimes hairy, 1.5–40 mm in length
- head prognathous, rostrum usually long and narrow, but can be short, stout and broad in some groups, often strongly sexually dimorphic in shape
- labrum not visible, maxillae and labium reduced, palpi rigid and tiny
- antennae usually straight with short scape
- prothorax without lateral carinae
- pygidium covered by elytra; first two abdominal ventrites fused
- tarsal formula: 5-5-5, but appearing 4-4-4

The Brentidae, formerly known as Brenthidae, is a rather large weevil family. Included here are the subfamilies Eurhynchinae, Nanophyinae, Cyladinae, and Apioninae, which were previously classed as families.

The Australian brentid fauna consists of more than 200 named species and most probably there are many more awaiting discovery and description.

The subfamily Brentinae are woodborers of freshly felled timber or live in the tunnels of other woodborers such as ambrosia beetles (Curculionidae: Platypodinae,

Ectocemus decemmaculatus (subfamily Brentinae) (12 mm) is a Queensland species, occuring also in the Philippines, New Guinea and neighbouring islands. Its biology is unknown. This specimen was photographed in a north Queensland rainforest.

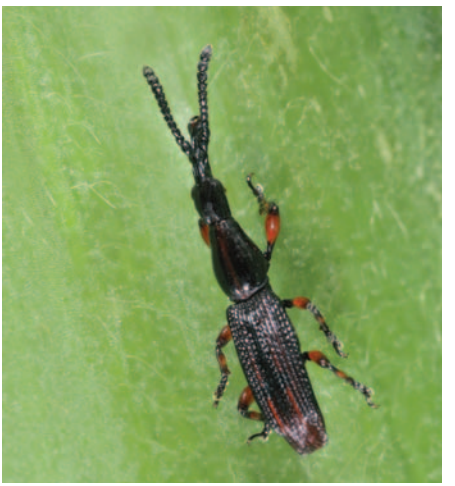
Very little is known about the habits and biology of the genus *Ankleineella* (subfamily Brentinae). Adults of most described species seem to be attracted to lights at night. This specimen (7 mm) was seen in a north Queensland rainforest.

Baryrhynchus lineicollis (subfamily Brentinae) (14 mm) occurs in Queensland and from the Moluccas to the Solomon Islands. Its larvae are known to tunnel in dead wood. This specimen was found in the Iron Ranges, north Queensland. Photo: O Kelly

Scolytinae); some are probably feeding on fungi. Others live in association with ants. The other subfamilies are mostly borers in softer plant tissue and one species, *Cylas formicarius*, is a major pest of sweet potato tubers.

The sweet potato weevil, *Cylas formicarius* (subfamily Cyladinae) (5 mm), is an introduced Asian species that is a pest of sweet potato, *Ipomoea batatas*. In Australia it occurs in Queensland, New South Wales and the Northern Territory.

Apion argutulum (subfamily Apioninae) (3 mm) occurs in Queensland, New South Wales and probably in the Northern Territory and Western Australia. Members of the genus *Apion* are distributed worldwide and some are pests of cultivated plants.



Miolispa australiana (subfamily Brentinae) (7 mm) can be found in Queensland, New South Wales and Victoria, and probably in New Guinea also. This specimen was photographed on a ginger fruit in north Queensland.

Cyphagogus delicatus (subfamily Brentinae) (4 mm) occupies the tunnels of its distant curculionid relatives, the ambrosia beetles, destroying the ambrosia beetles in the process. Its host plant is *Eucalyptus saligna*. It occurs in Queensland, New South Wales, Victoria, Tasmania, and also in New Guinea.

Curculionidae

Weevils or snout beetles

- body shape diverse, but generally convex, exoskeleton strong and hard, often with scales and bristles, 1.5–65 mm in length, but usually less than 12 mm
- some species (Scolytinae, Platypodinae) cylindrical with short or absent rostrum, resembling Bostrichinae
- head usually with forward or downward projecting rostrum, ranging from short and broad to narrow and long
- antennae almost always elbowed, with long scape and 3-segmented club
- first two ventrites fused
- tarsal formula: 5-5-5, but appearing 4-4-4

The Curculionidae are known as the 'true' weevils. They form the largest animal family of the world, including more than 40 000 described and probably the same number of yet undiscovered, unnamed species. About 6500 described species are known from Australia.

Despite their many different colours and shapes, most curculionids are quite easily recognised. Their most obvious characteristic is the rostrum, but their elbowed or geniculate antennae with small clubs is also distinctive. They are mostly slow-moving beetles, often pretending to drop dead when alarmed. Many of them are flightless, although some species can fly very well. Quite a few species are attracted to lights at night, but most of them avoid strong sunshine during the day.

The adults of most species are to be found on live plants where they feed on the foliage or other parts of their food plants, but also in leaf litter and in other accumulations of plant debris. Members of the subfamilies Platypodinae and Scolytinae are wood-boring fungivores.

The larvae of a very few curculionids subsist in the dung of some macropods. Weevils are often host-plant specific and the larvae usually feed inside their host plants, either in the stems or leaves, seeds or seed pods. Curculionid larvae are phytophagous or mycetophagous, some are serious pests of agriculture, and also forestry and stored products, while others are beneficial destroyers of weeds.

The classification of this fascinating and diverse family is very complex. Five of the six currently recognised subfamilies are included here.

The Botany Bay diamond beetle, *Chrysolopus spectabilis* (subfamily Brachycerinae) (24 mm), occurs in Queensland, New South Wales, Victoria and South Australia. Its host plants are several species of *Acacia*. The larvae bore into the roots of the plants, while the adults feed on the twigs and foliage. They are slow-moving beetles, often feigning death if disturbed.

This desert ground weevil of the genus *Acantholophus* (subfamily Brachycerinae) (14 mm) has a thickened exoskeleton that gives it extra protection against heat and dehydration. Photo: O Kelly

The cryptic colours of *Leptopius clavus* (subfamily Brachycerinae) (12 mm) help it to blend into the dry leaf litter of the open forests. Species of this genus are found in most parts of Australia.

Catasarcus carbo (subfamily Brachycerinae) (6 mm) has the characteristic features of an arid zone dweller: a heavily sclerotised integument and long legs which it uses to elevate itself from the hot surface of the ground. There are about 60 species in this genus, almost all occurring in Western Australia.

The peculiar short snout of *Leptopius quadridens* (subfamily Brachycerinae) (15 mm) gives it its common name 'wattle pig'. However, not all *Leptopius* spp. are associated with wattles. The specimen was found in coastal forest, north Queensland.

This species of the genus *Leptopius* (subfamily Brachycerinae) (15 mm) lives mainly on the ground, feeding on low plants. It lives in the dry heat country of the arid plains near Perth.

Talaurinus fergusoni (subfamily Brachycerinae) (20 mm) is a knobby ground weevil from Mt Norman, Queensland. It is well adapted to the arid zone with its heavily sclerotised integument. Photo: O Kelly

This is a forest-dwelling species of the genus *Leptopius* (subfamily Brachycerinae) (12 m) from near Kuranda, north Queensland. An interesting feature of this genus is that its members are wingless.

The black clown weevil, *Pantorhytes stanleyanus* (subfamily Brachycerinae) (8 mm), has a shiny black exoskeleton and very short, blunt rostrum. It is a rainforest species, found in north Queensland.

The attractive members of the genus *Myllocerus* (subfamily Brachycerinae) are clothed with bluish scales. They are foliage feeders and most species of the genus live in the warmer parts of Australia. This specimen (6 mm) was found in a north Queensland rainforest.

Some of the short-nosed weevils of the genus *Gonipterus* (subfamily Brachycerinae) have spread overseas through human commerce and have become pests of eucalypt plantations in New Zealand, South Africa and South America. This specimen (8 mm) was found in Sydney.

This spiny weevil of the genus *Gonipterus* (subfamily Brachycerinae) (6 mm) lives in the rainforests of north Queensland. Unusual for weevils, the larvae of *Gonipterus* species are external feeders of foliage.

Miltotranes prosternalis (subfamily Curculioninae) (3 mm) is associated with cycads. This one is on the fruit of *Bowenia* sp. in north Queensland. Adults often frequent the flowers too.

The success story of the salvinia weevil

The salvinia weevil, *Cyrtobagous salviniae*, is an introduced species in Australia, Papua New Guinea and in a number of other tropical countries. This tiny South American beetle was employed to restore the natural environments of rivers, lakes and wetlands, where an accidentally introduced Brazilian aquatic plant, the giant salvinia or kariba weed, *Salvinia molesta*, choked all open water surfaces.

Salvinia forms a thick, continuous carpet over the surface of the water, blocking sunlight needed by other aquatic plants and especially algae to oxygenate the water. It also blocks irrigation, causes flooding and pollutes drinking water. Only mosquitoes benefit, as the water trapped by the thick mat of vegetation becomes an ideal breeding place for these disease-carrying insects.

Destruction of large infestations by physical means, such as removing the plants by dredging and excavation, and by spraying it with chemicals proved to be difficult, expensive and often impossible.

Biological control, however, brought better results. Following extensive research by CSIRO, the introduction of *Cyrtobagous salviniae* was very effective, especially in tropical and subtropical climates. The female lays over 300 eggs one by one in the lower leaves and rhizomes (the horizontal stems) of the salvinia plant. The white, soft larvae feed voraciously inside the stems and the adults eat the buds, warping and stunting the plant until it eventually sinks.

The beetle was first released in 1980 into the heavily infested Lake Moondarra near Mount Isa, Queensland. About 800 hectares of salvinia mat, weighing tens of thousands of tonnes was almost totally destroyed by the quickly multiplying weevils within a year. *Cyrtobagous salviniae* was released since in many other parts of Australia, with more or less the same success.

The adult salvinia weevil, *Cyrtobagous salviniae* (subfamily Curculioninae) (2 mm).

Larva of the salvinia beetle, *Cyrtobagous salviniae* (subfamily Curculioninae) (4 mm).

The species *Nototragopus plagiatus* (subfamily Curculioninae) (18 mm) lives in north Queensland, where it was photographed.

Salcus elevatus (subfamily Curculioninae) (4 mm) is a rainforest species from north Queensland. Its habits and biology are not known.

Some species of the genus *Alcidodes* (subfamily Curculioninae) are known as pests of sweet potato, *Ipomoea batatas*. This specimen (16 mm) was found in the north Queensland rainforest where it probably feeds on indigenous Convolvulaceae.

Members of the genus *Eutyrhinus* (subfamily Curculioninae) (4 mm) may be considered as 'ring-barking' pests of various tropical fruit plants. It seems to mimic a bird dropping in order to escape the attention of predators.

The elephant weevil, *Orthorhinus cylindrirostris* (subfamily Curculioninae) (18 mm), occurs just about everywhere in Australia. Although eucalypts are its indigenous food plants, it has became a pest of grape vines. The larvae tunnel in the vines and the adults nibble on the buds, fresh shoots and can ringbark new growth.

The giant pine weevil, *Eurhamphus fasciculatus* (subfamily Curculioninae) (60 mm), is our largest curculionoid species. It inhabits the rainforests of south-east Queensland mostly on bunya pine (*Araucaria bidwillii)* and hoop pine (*A. cunninghamii)*. This specimen was photographed in the Lamington National Park, Queensland. Photo: O Kelly

Trigonopterus albidosparsa (subfamily Curculioninae) (3 mm) is a rainforest weevil from north Queensland. It was photographed near Cairns.

Meriphus australis (subfamily Curculioninae) (5 mm) has an unusually long rostrum. It is a flower-frequenting species of Western Australia.

Species of the genus *Eutinophaea* (subfamily Curculioninae) are leaf-eating weevils. This specimen (8 mm) was photographed near Cairns, Queensland. *E. bicristata* – a closely related species to the one pictured here – is a minor pest of citrus in Queensland and New South Wales.

Myllorhinus insignis (subfamily Curculioninae) (6 mm) imitates a spine or a bud on the stem of a plant. This specimen was found in a remnant rainforest near Bowden, Queensland. A related species, the shoot borer weevil, *M. dentiferus*, causes damage in coppiced eucalypt regrowth.

The mango pulp weevil, *Sternochetus frigidus* (subfamily Curculioninae), is an introduced pest of the mango, occurring in south and South-East Asia, as well as New Guinea. The larvae feed in the pulp and pupate in a chamber that it excavates within the fruit.

This undescribed species of the genus *Rhynchaenus* (subfamily Curculioninae) is known as a 'jumping weevil'. With its well-developed hind femora, it can jump like a flea. This specimen (2 mm) was photographed in north Queensland.

One of the most destructive pests of stored grain is the rice weevil, *Sitophilus orizae* (subfamily Dryophthorinae) (3 mm). Adults live for about four to five months, during which a female may lay 300–400 eggs. In a warm place development from egg to imago can be as short as 26 days.

The maize weevil, *Sitophilus zeamais* (subfamily Dryophthorinae) (3 mm), infests all kinds of stored grain, but its preferred food is rice. The larva feeds inside the grain, hollowing it out and destroying it in the process, by the time the adult emerges. Its habits and lifecycle are similar to the rice weevil, *Sitophilus orizae*.

The banana root weevil or banana weevil borer, *Cosmopolites sordidus* (subfamily Dryophthorinae) (6 mm), lays its eggs between the leaf sheaths and stems, as well as around the corm. The newly hatched larva bores into the tissues and develops within. The complete lifecycle is from 30 to 40 days. Adults can fly and disperse easily.

This spectacular weevil, *Iphthimorhinus australasiae* (subfamily Dryophthorinae) (35 mm), occurs in Queensland, the Northern Territory and also New Guinea, where it is associated with palms and *Pandanus* species. The female is showing her typical, 'flamingo-like' rostrum. Males do not have such impressive organs, but have orange-coloured coarse beards instead.

The polyphagous pinhole borer, *Platypus australis* (subfamily Platypodinae) (4 mm), is one of the ambrosia farmers. It occurs in Queensland and New South Wales. This specimen was found near Cairns, Queensland.

The island pinhole borer, *Xyleborus perforans* (subfamily Scolytinae) (2.8 mm), occurs in Queensland. It has become a pest of various fruit trees by boring into the trunks and branches.

Farmers of ambrosia

Ambrosia was the food of the gods in ancient Greek mythology. On Earth, some weevils also live on such nourishing substance – they even grow their own. Members of two subfamilies of Curculionidae: Scolytinae and Platypodinae live in nutritional symbiosis with ambrosia fungi.

Most species of Platypodinae are not host-specific and may associate with just about any ambrosia fungi (*Ambrosiella*, *Rafaella, Dryadomyces* spp.). The adult beetles bore into moribund or recently dead trees and excavate tunnel-like galleries in them. Most species don't consume any of the wood they chew, but remove the resulting frass from the excavated passages. The beetles carry the spores of the ambrosia fungi and they release these in the galleries. The developing fungi penetrate the sapwood and/or heartwood of the plant and obtain and concentrate nourishment from it.

Both adults and larvae graze on the vegetative parts (mycelia) of the fungi. Larval development and pupation takes place in the galleries. The emerging imagos gather quantities of spores in their specialised organ known as mycangia and soon aftrewards leave their birthplace to look for another site where they can start their own colony.

The scolytine weevils or bark weevils are often regarded as ambrosia beetles, although their habits are somewhat different from those of the platypodines. They often tunnel just under the bark of trees, excavating complex galleries of species-specific patterns. The Scolytinae can pose significant danger to forestry as their populations often build up to high level, causing serious damage to trees.

This is an ambrosia grazing pinhole beetle of the genus *Platypus* (subfamily Platypodinae) (4 mm). When the 'duck-billed platypus' was scientifically described by George Shaw in 1799, it was given *Platypus* as a generic name. However, the German anatomist Johann Friedrick Blumenbach had already assigned this name to a group of pinhole borers. According to the rules of taxonomic priority, the beetles could keep their original name and the 'duck-billed platypus' was re-named as *Ornithorhynchus*.

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Glossary

abdomen hindmost and usually the largest section of the three distinct parts of the insect body; it contains the reproductory organs and most of the digestive and excretory organs

alimentary canal the food tube traversing the body from the mouth to the anus

amphiodont a form of male stag beetle (Lucanidae) with mandibles of medium size, between the telodont and priodont forms

anal in the direction of, pertaining or attached to the anus or to the last segment of the abdomen

angiosperm flowering plant

ante- Latin prefix; before

antenna (pl. **antennae**) the paired segmented sensory organs, borne one of each side of the head

antenomeres antennal segments

anterior in front; before, forward-facing

apex (pl. **apices**) tip of a structure

apical the region at or adjacent to the tip of a structure

apodus without legs

aposematic colouration usually bright, warning colouration

arthropods (**Arthropoda**) animals with jointed legs

asexual reproduction the production of viable offspring without fertilisation of eggs by sperm

basal at or pertaining to the base of to the base or point of attachment to or nearest the main body

biconvex double convex, ball-like

billabong a section of still water adjacent to a river, cut off by a change in the watercourse

bilobed divided into two lobes

biodiversity the diversity of all life forms

biological control the deliberate control of damaging animals or any other life forms by the introduction of a species (e.g. an insect) that naturally preys on the unwanted species

brachelytrous having short elytra

bristle a short, stiff hair

campodeiform applied to larval forms which resemble Campodea

carina (pl. **carinae**) an elevated ridge or keel

carinate keeled; with one or several longitudinal raised lines

cercus (pl. **cerci**) jointed, generally paired appendages at the tip of the abdomen

cervical relating or belonging to the neck

cervix the upper part of the neck

chitin a strong, flexible, fibrous substance which is the basis of the exoskeleton of arthropods

chorion the outer shell or covering of the insect egg

class the taxonomic category between phylum and order

clavate, clavatus clubbed; thickening gradually toward the tip

club in the insect antennae, the more-or-less enlarged distal segments

clubbed see clavate

clypeus part of the insect head, in front of or below the frons

coarctate pupa a pupa which remains enclosed in the larval skin

cocoon a covering, composed partly or wholly of viscid fibre

commensal two species live together; one benefits positively; the other unharmed

complete lifecycle complete metamorphosis, in which the insect passes through four distinct stages (egg, larva, pupa, and imago)

Note: This glossary is based mostly on Torre-Bueno JR (1989). *A Glossary of Entomology.* New York Entomological Society, New York.

compound eye an eye consisting of many hexagonal facets, each one serving as a single corneal lens

concave, concavus hollowed out; the interior of a sphere as opposed to the outer or convex surface

contractile capable of being drawn together or contracted

convex the outer curved surface of a segment of a sphere, opposed to concave

coppicing a traditional method of woodland management in which young tree stems are repeatedly cut down to near ground level

coprophagous feeding on excrement

corm short, vertical, swollen underground plant stem that serves as a storage organ used by some plants to survive adverse conditions such as summer drought and heat

coxa (pl. **coxae**) the basal segment of the leg, by means of which it is articulated to the body

crepuscular active at dusk

crochet (pl. **crochets**) the curved spines or hooks on the prolegs of caterpillars, on the cremaster of pupae, and on the abdomen of coccinellid larvae

cruciform cross-shaped

cryptic hidden, concealed, protective colouration facilitating concealment

cupule a cup-shaped organ

cupuliform cup-shaped

cuticle, cuticula the outer covering of an insect

decumbent bending downward, bending down at tip from an upright base

deflexed pointing downwards

defoliate to extensively strip leaves off a plant

dehiscent open or standing open; separating toward the tip

detritus broken-up and usually decaying organic matter, mainly of plant, but also of animal origin

diapause arrested growth and development during unfavourable conditions

dicotyledon member of the group of flowering plants whose embryos have two cotyledons

dimorphism (sexual) males and females of the same species having difference in form, colour, size, etc.

distal near or toward the free end of any appendage; that part of a segment farthest from the body

diurnal active during the daylight hours

dorsal of or belonging to the upper surface

ecdysis the process of an insect casting off its old cuticle or exuvia

ecosystem the populations of flora and fauna and their environment functioning as an interdependent unit

ectoparasite a parasite living on a host's skin

elbowed antennae those bent at an angle near the middle

elytron (pl. **elytra**) the hardened forewing that protects the membranous hind wing in beetles

emarginate notched; with an obtuse, rounded or quadrate section cut from a margin

emargination a cut-out place in an edge or margin

endemic a native to, and restricted in

endo- Greek prefix; within

endoparasite a parasite living within the body of its host

eruciform like a caterpillar in form or appearance

eudicotyledon member of a group of flowering plants, previously called 'tricolpates' or 'non-Magnoliid dicots'; the term means, literally, 'true dicotyledons' as it contains the majority of plants that have been considered dicotyledons

eversible capable of being turned outward or inside out

exoskeleton the armour-like outer 'skin' of arthropods; cuticle; integument

explanate spread out and flattened; applied to a margin

extruded pushed or forced out

exuvia (pl. **exuviae**) empty nymphal skin

family the taxonomic category between an order and a genus

femur (pl. **femora**) the thigh; usually the stoutest segment of the leg

feral escaped from domestication and reverted to a wild state

filiform thread-like (usually used to describe antennae)

flabellate, flabelliform fan-shaped, with long thin processes lying flat on each other like the folds of a fan

fossorial adapted for digging (usually used to describe certain types of legs)

frass plant fragments produced by wood-boring insects, usually mixed with excreta

frons the front part of the insect head, between the eyes

frontoclypeal of or pertaining to the frons and the clypeus together

fungivore fungus eater

fusiform spindle-shaped; broad at the middle and narrowing toward the ends

ganglia (sing. **ganglion**) a nerve centre composed of a cell mass and fibres

geniculate knee jointed; abruptly bent in an obtuse angle

genus (pl. **genera**) the taxonomic category between family and species

gill a special, variously formed respiratory organ in the aquatic immature stages of many insects

glabrous smooth, hairless and without punctures and structures

globular spherical, perfectly round in all direction

Gondwana the ancient supercontinent, which included the land masses of Australia, South America, Africa, India, Antarctica and New Zealand

gula the throat sclerite forming the central part of the head beneath

gular of or pertaining to the throat or gula

haemolymph the insect's blood

hemispheric, hemispherical shaped like half a globe or sphere

herbivore, herbivorous plant-feeding animal

hirsute hairy

host an animal or plant, which is a food source for a parasite

hypertrophy abnormal enlargement or excessive development

hypha (pl. **hyphae**) of fungi, the threads

hypognathous having the head vertical and the mouth directed ventral

imago (pl. **imagos**) the adult, or perfect stage of an insect

incomplete lifecycle the process where the young (nymphs) are somewhat similar in appearance to adults and develop gradually without a pupa stage

integument the outer covering of an insect; exoskeleton; cuticle

instar one stage of growth between moults

invertebrate an animal without a backbone

labial palps segmented palps, located on each side of the mouth in front of the maxillary palps

labium lower 'lip', paired mouthparts fused together to form a plate-like structure

labrum sclerotised upper lip-plate, hinged to the clypeus above the mouth

lamella (pl. **lamellae**) a thin plate of leaf-like process

lamellate antenna one with the club formed of closely opposed leaf-like surfaces

lamina (pl. **laminae**) a thin flat chitinous plate, scale or layer

larva (pl. **larvae**) grub-like, pre-pupa stage of endopterygotes (e.g. beetles)

lateral pertaining to the sides

lobe, lobus (pl. **lobi**) any prominent rounded process on a margin or structure

luciferase a substance in the nature of an enzyme, existing in the luminous organs of light-giving beetles

longitudinal in the direction of the long axis

keel an elevated ridge or carina

Malpighian tubes or **organ** long and slender excretory tubes of insects, opening into the hind intestine; the insect urinary system

mandibles pair of chewing mouthparts (jaws)

mandibulate with biting and/or chewing mouthparts

margin the more or less narrow part of a surface within the edge, bounded on the inner side by the submargin

marginal of, belonging to, or near the margin

marginate margined, bounded by an elevated or attenuated margin

maxilla (pl. **maxillae**) the second pair of jaws in a mandibulate insect

maxillary attached or belonging to the maxilla

maxillary palps the pair of palps carried by the stripes on its outer end; appendages of the insect maxilla, sensory in function

median in or at the middle

membranous thin and transparent

mentum the distal sclerite of the insect's labrum, bearing the moveable part

mesodont in male stag beetles (Lucanidae), mandibles intermediate in size between the telodont or large, and the priodont or small mandibles

mesonotum the middle dorsal sclerites of the thorax

mesothorax the middle segment of the thorax

metamorphosis the transformation through various stages from egg to imago

metanotum the posterior dorsal sclerites of the thorax

metasternum the underside or breast of the metathorax

metaventral the posterior section of the abdomen's underside

metathorax the third thoracic ring or segment, which bears the hind legs and second pair of wings (if present)

molar, mola the ridged or roughened grinding surface of the mandibles

moniliform string of bead-like (used to describe antennae)

monocotyledon member of the group of flowering plants whose embryos have only one cotyledon

monotypical genus a genus formed of one species only

moribund mortally ill, destined to die

morphology anatomy, structure

moult the shedding of the outgrown cuticle or exoskeleton during the process of growing

mycetophagous feeding upon fungi

natorial adapted to swimming (usually used to describe the nature of particular insect legs)

necrophagous feeding on dead and/or decaying matter

nocturnal active at night

notopleural suture suture on the upper surface of the thorax

nuptial flight flight taken by insects when mating takes place

nymph the larval form of an insect which develops through incomplete metamorphosis

obligate, obligatory a parasite or a symbiont living with one specific host or symbiont

obligatory parasite a parasite living on one host (or in one host's nest) exclusively

occiput the back section of the insect head

ocellus (pl. **ocelli**) a simple, single-lensed eye

olfactory pertaining to the sense of smell

omnivorous eats just about everything (e.g. animal and plant tissues)

opisthognathous having head bent down so much that mouthparts point towards the rear

order the taxonomic category between class and family

osmosis the tendency of liquids to pass or diffuse through a membrane

ovary (pl. **ovaries)** the mass of ovarian tubes lying one of each side of the body cavity of the female insect, in each of which the eggs are developed

oviduct one of the paired tubes through which the egg passes from the ovarian tubes into the vagina

ovipositor egg laying organ

ovum (pl. **ova**) egg or female cell capable of developing a new individual

palps (pl. **palpi**) appendages around the mouthparts; part of the complex sensory and feeding organs

parasite organism that feeds on another living organism (host)

parasitoid organism that feeds on another living organism (host) eventually killing it

parthenogenesis reproduction from unfertilised eggs

pectinate comb-like

pedicel the part of the antenna between the scape and flagellum; a narrow, stem or stalk-like structure supporting another organ or structure

pellets undigested matter (e.g. bones, fur, feathers, chitinous remnants, etc.) regurgitated by carnivorous and insectivorous birds and mammals

penultimate next to the last

perfect insect imago; adult form of an insect

pheromone chemical secretion of an animal which influences the behaviour of another member of the same species; especially employed to attract the opposite sex

phloem tissue in plants that conducts food from sites of synthesis or storage to sites where food is used or stored

phytophagous plant eater

plastron a layer of fine hair on the underside of some aquatic insects, which holds a layer of air

pollination the deposition of pollen on or near the female parts of flowering plants

polymorphic occurring in several forms

posterior situated behind

predaceous hunts and eats other animals

priodont a form of male stag beetle (Lucanidae) which has the smallest mandibles

pro- Latin prefix; anterior, before, forward, fore or forth

process a prolongation of the surface, of a margin, or of an appendage; any prominent part of the body not otherwise definable

produced drawn out; extended; shown

prognathous having the head horizontal with jaws directed forward

proleg any process or appendage that serves the purpose of a leg; abdominal feet, false legs

prominence a prominent process or structure

prominent raised or produced beyond the level of a margin, standing out in relief by colour or otherwise; conspicuous

pronotum dorsal surface of the first segment of the thorax

propygidium the tergite anterior to the pygidium especially in beetles with short elytra; the seventh tergum in beetles

prosternum the fore-breast

prothorax the front part of the thorax

protibiae tibiae of the first pair of legs

pseudo- Greek prefix, false, merely resembling

pseudotetramerous seemingly four-jointed tarsi

pubescence short, fine erect hair or down

pubescent downy, clothed with short, fine hair

pygidium the last dorsal segment of the abdomen left exposed by the elytra in beetles

quadrate square or nearly so

recumbent lying down, reclining

rostrate having a rostrum, a long, snout-like prolongation of the head

rostrum a rigid extension of the head, a long protraction bearing the mouth parts

sclerite any part of the insect's body wall, bounded by sutures

sclerophyll a type of vegetation that has hard leaves and short internodes (the distance between leaves along the stem)

scutellum the triangular piece between the elytra (in beetles)

seminal fluid sperm; spermatozoa,

seminal vesicles enlarged tube- or pouch-like structures which serve to store the seminal fluid of the male

sensilla sense organ

sensoria circular opening covered by membrane

serrated saw-like shape

seta (pl. **setae**) slender bristle rising from a socket

setose covered with setae

social insects living in more or less organised communities of aggregation of individuals, generally with differentiated castes, as certain Hymenoptera

sp. (pl. **spp.**) abbreviation for species

species the taxonomic category below genus

sperm the seminal fluid; spermatozoa

spinose spiny; armed with spines

spiracle small breathing hole (pore), positioned on the sides of the insect abdomen and thorax

spore one of the reproductive bodies of the lower plants

sternites ventral sclerites of any segment

sternum breast

stria (pl. **striae**) fine longitudinal depressed line or furrow, often punctured, extending from the base to the apex of the elytra

sub- Latin prefix, meaning under; slightly less than; or not quite so

suture a seam or impressed line marking the division of the distinct parts of the body wall; the line of conjuncture of the elytra in beetles

symbiont an insect or other arthropod living in symbiosis with termites or ants or other insects

symbiosis different species living together in more-or-less close association

tergite a dorsal sclerite

tetramerous having four-jointed tarsi

thanatosis feigning death

tibia (pl. **tibiae**) the fourth division of the leg, articulated at the proximal end of the femur and bearing the tarsi on the distal end

trachea (pl. **tracheae**) the tube conducting air from the outside through the interior of the body

transverse broader than long; running across; cutting the longitudinal axis at right angles

trochanter a sclerite of the insect leg, sometimes divided, between the coxa and femur; sometimes fused with the femur

trophallaxis exchange of nourishment, one insect with another, either of the same species or different species

truncate cut off squarely at tip

tubercle a little, solid pimple or button

tuberculate tubercle-like, furnished with tubercles

tympana, tympanal or **tympanic organ** the auditory organ of an insect

urogomphi (sing. **urogomphus**) protruding processes found on the terminal segments of some larvae

vein a structural wing strut, often tubural, containing a trachea and haemolymph

venation the system of veins/tubes of the insect wing

venter the belly, the whole ventral surface of the abdomen

ventral pertaining to the undersurface of the abdomen

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